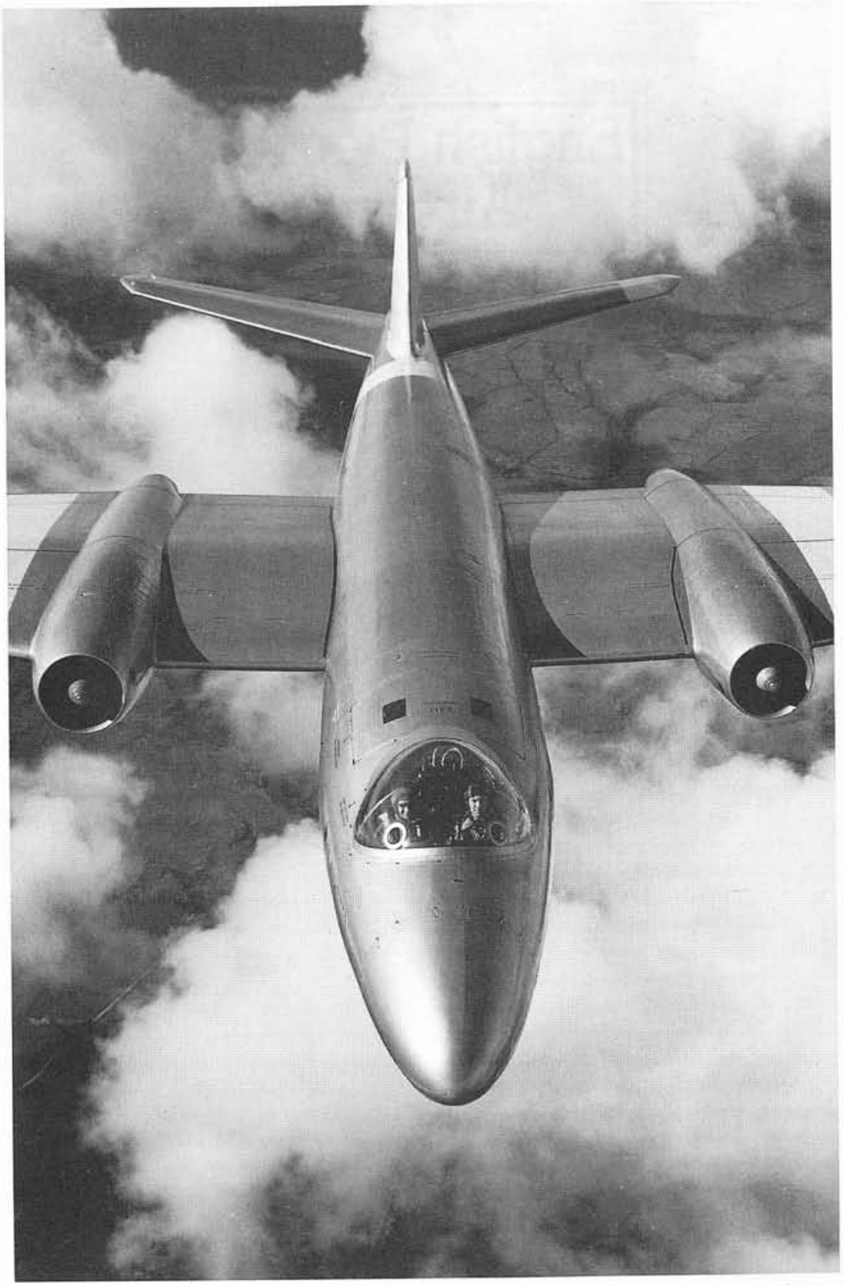
English Electric Aircraft

and their Predecessors

Stephen Ransom

Robert Fairclough



The Canberra, one of the most beautiful aeroplanes ever built, made its first flight on 13 May, 1949, and established English Electric in the front rank of aircraft manufacturers. More than 1,300 Canberras were built and the type has been in service for well over three decades. The example illustrated is the Canberra T Mk 4, which first flew on 12 June, 1952.
(Charles E. Brown, Courtsey The English Electric Co Ltd)

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PUTNAM

'I am of the opinion that the aircraft industry is ahead of others in the application of science.'
W.O. Manning (1925)

'It seems probable that no other single industry would have such a pervasive effect on the technological progress of the nation.'
Plowden Committee on Aviation (1965)

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The authors cannot claim to have initiated this history although they have very considerably enlarged upon and entirely rewritten beyond recognition the original work by H. Bonney and G.L.C. King, who began their research in 1954. They produced a first draft of the book but were unable to complete the history owing to pressure of work and other commitments. In 1964, the combined mutual interests of the present and past authors led to a decision to continue writing the history. Harry Bonney and Geoffrey King generously donated their own material and this was used as the basis for this book. The authors thank them for their assistance and those who helped them with their research.

Although this history has remained a private venture throughout the period in which it was written, the authors have of necessity had recourse to the records and facilities available within British Aerospace, Warton Division. The authors gratefully acknowledge the Division's directors for giving their permission to obtain access to relevant documents and for the use of the various facilities. In particular, they thank the former directors F.D. Crowe and W. Shorrock, Senior, for their constant support and encouragement. The authors wish to state, however, that the views expressed in the book are their own and are not necessarily those held by the companies concerned in this history.

When the authors commenced their research they were surprised and to some degree saddened to find that authentic records pertaining to the company's early history were virtually non-existent. On reflection, they realised English Electric's history was such that the various events which led to its formation and expansion, that is, mergers, take-overs and liquidations, inevitably created problems of storage of even essential documents. Generally these papers were destroyed intentionally to make way for current transactions. Others were lost accidentally, as for instance in the fire at the Dick, Kerr Works at Preston, in the 1930s which destroyed personnel records, the drawing office and, it is believed, remnants of aircraft components dating back to the early 1920s. To have relied solely on readily accessible information would have been a mistake because a number of errors would then have been perpetuated. The authors, in search of historical accuracy, therefore, attempted to trace original material which they believed to be held in private and public archives. This arduous and lengthy task was rewarded by the location of a great many hitherto unknown documents and photographs and the privilege of meeting and corresponding with a number of former employees, whose vivid memories helped to untangle many a Gordian knot. Records concerning the more recent phase of the company's history have been preserved and the problems involved in compiling these, though complex, have proved less difficult. However, much information was again obtained from private sources in order to present as complete a picture as possible.

We especially wish to thank: James Barton, Leonard Brown, Jack Bruce, William Garlick, Victor Gaunt, Michael Goodall, Philip Jarrett, Henry Knowler, Stuart Leslie, Dennis Manning, Mrs Elfrida Manning and Bruce Robertson. Without their generous assistance the early history could not have been written.

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Our thanks are also due to Robert Thornley, whose photographic skill preserved a large number of the photographs used to illustrate the company's early history, and Mrs Barbara Smith, who typed the original manuscript.

Finally, special mention must be made of Mrs Stephanie Ransom, who greatly assisted with the research for, the preparation and editing of and the final typing of this history.

SR — April 1987 — RSF
Bremen, FRG — Blackburn, UK

Introduction

The English Electric Company was not established solely to manufacture aircraft. It was incorporated in 1918 to amalgamate the various electrical and mechanical engineering interests of five firms. These concerns—Dick, Kerr & Co, the Phœnix Dynamo Manufacturing Co, the Coventry Ordnance Works, Willans & Robinson and the United Electric Car Co—were each in the forefront of their own spheres of industry, both at home and abroad. Aircraft and ancillary items were just one facet of their work and this occupied them all for a short period only of their history. English Electric formed its own aircraft department soon after amalgamation but Government economies affecting the strength of the Royal Air Force led to its closure in 1926. It was reformed in 1938, however, to help expedite the Government's plans for rearmament. In 1959, a subsidiary company, English Electric Aviation Ltd, was formed to encompass the parent company's aviation interests. Five years later, the name of English Electric disappeared from the aircraft industry, its place being taken by British Aircraft Corporation, Preston Division, and subsequently by British Aerospace, Warton Division. Aircraft design, development and production did not end with a change of name: Warton is now deeply involved in various international collaborative projects.

The first phase of English Electric's aviation history had its origin in an aircraft factory established by Howard T. Wright at Battersea, London, in 1907, and revolves around the work of W.O. Manning, a pioneer of the present industry. From 1908, when Manning joined Wright until the time he left English Electric in 1926, there is a continuous line of development of his wide-ranging ideas. Manning became in turn chief aircraft designer to Coventry Ordnance Works (COW), the Phœnix Dynamo Co and English Electric.

The second phase of the company's history in many respects mirrors the first. During the 1914–1918 war, large contracts were placed with COW, Phœnix and Dick, Kerr. It can be said that these contracts paved the way for work in which English Electric was to excel, namely the mass-production of airframes under sub-contract. English Electric recommenced aircraft production in 1938 with this type of work. Sub-contracting during both the first and second phases led to the formation of English Electric's design teams in 1918 and again in 1944. The second phase ended in the 1960s, when the Government's measures for the rationalisation of the British aircraft industry took effect, and English Electric Aviation became part of the British Aircraft Corporation. Another era of development and success was to follow, but that is another story.

The Company's History

Early Days

I

Howard Theophilus Wright was born at Dudley, Worcestershire, in 1867, the second child of Grace Elizabeth and Joseph Wright. He had an elder sister, Grace Ellen, and two younger brothers, Warwick Joseph and Walter Stanford. He was educated at Manor House School and served an apprenticeship at his father's works, Joseph Wright & Co, which was alongside the canal at Tipton, Staffordshire. In 1889, the part of the works known as the Boiler Yard was sold to Hiram S. Maxim (later Sir), an entrepreneur of many interests including aviation, and Howard Wright became its manager. This led, on 6 May, 1899, to the formation of the Maxim Electrical & Engineering Export Ltd, and Howard continued as manager of its engineering department. At the turn of the century the Wright family moved to London. By then Howard was actively assisting Maxim with designs for steam generators and boilers and with Maxim's aerodynamic experiments using a whirling arm, and he interested himself in turbines. Meanwhile, Warwick and Walter Wright had formed an agency to promote their interests in motor cars.

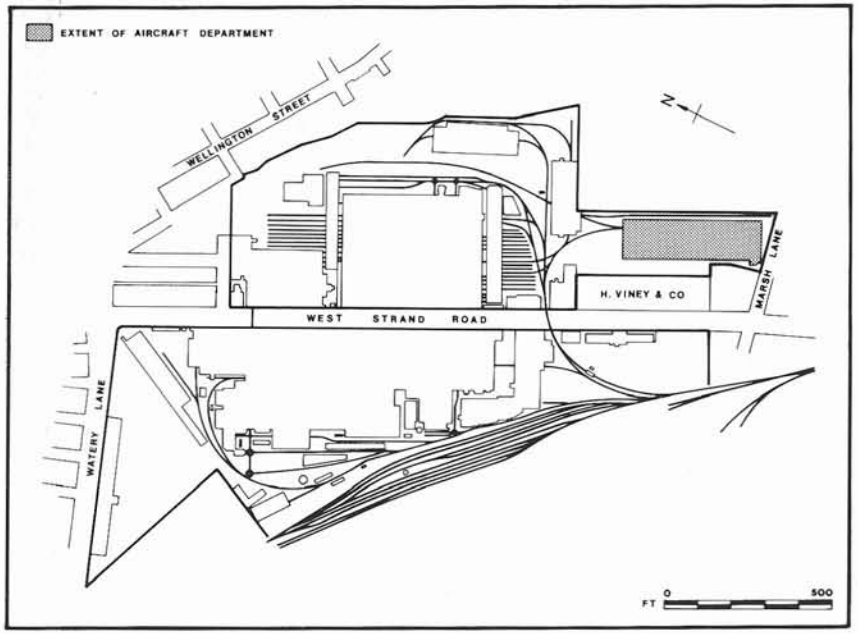
In November 1904, Howard Wright's association with Maxim ended when Howard bought back his own goodwill upon liquidation of Maxim's company. On 31 July, 1905, the various businesses of the Wright brothers were brought under the control of one company—Howard T. Wright Brothers Ltd. The company was registered with an office at Belgravia Chambers, 72 Victoria Street, London, S.W. 1, and an authorised capital of £10,000. Howard Wright and James Nicholson, an engineer, were joint managing directors, Warwick was appointed manager, and Walter, secretary, Henry Claude Walker being elected chairman. In November 1905, J.T.C. Moore-Brabazon, later Lord Brabazon of Tara, was elected a director. However, the company was short-lived, a resolution for voluntary liquidation being passed in October 1907. In the meantime, on 28 November, 1906, a new concern named Warwick Wright Ltd had been established with an office at 110 High Street, Marylebone, N.W. 1, and a capital of £26,000, to act as motor car agents and manufacturers. The brothers again held predominant interests in the company and Moore-Brabazon was appointed its vice-chairman.

Early 1907 saw an event of far-reaching consequences when a letter addressed to the defunct Maxim company was forwarded to Howard for his attention. The letter signed by Federico Capone, an Italian inventor, asked whether a special flying machine could be made for him. The ensuing correspondence resulted in Capone sending sketches of a twin-rotor helicopter and enquiring the cost of its construction. Howard studied the design during the summer and, on deciding that he could undertake the work, a contract was drawn up and the cost agreed at £2,500. Construction

of the helicopter was started in November in a shed on the Marylebone premises and completed in the following March at Battersea, where a workshop had been acquired by Warwick Wright Ltd early in 1907. The workshop occupied one of several large arches beneath the London Brighton and South Coast Railway, overlooking the gasworks adjacent to Queenstown Road.

II

Over the workshops, trains carried passengers between London and its southern environs: electrification of the line was to take place within the next few years. A supplier of electrical equipment for this project was Dick, Kerr & Co Ltd, a firm associated with railways since its formation in 1875 by two Glasgow merchants, W.B. Dick and John Kerr. By the end of the century, the company was supplying not only railway and tramway equipment but also was engaged in the heavy engineering industry and was exporting its products world wide. In November 1883, Dick left the firm because of other interests. His name, nevertheless, was retained in the title



Dick, Kerr & Co Ltd's Works, c 1918.

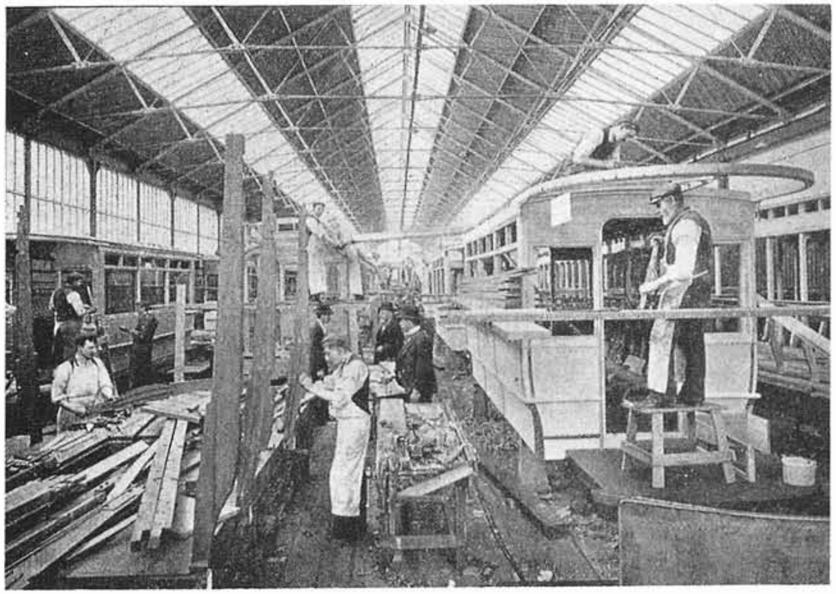
of the company when a new partnership was formed between Kerr and Frederick Manuelle. The following years saw Dick, Kerr enter and play increasingly important parts in electric traction schemes throughout the country. These and the firm's other commitments inevitably led to its reconstruction and on 31 May, 1890, Dick, Kerr & Co Ltd was incorporated as a public company with a capital of £160,000.

West Strand Road, later renamed Strand Road, Preston, in the early 1900s. On the left is the factory acquired by Dick, Kerr & Co from The English Electric Manufacturing Co and on the right, the Carriage Works. (*The English Electric Co Ltd*)

In 1897, Dick, Kerr acquired a disused factory on the east side of Strand Road, Preston, for the production of electric tramcars. A separate company, The Electric Railway & Tramway Carriage Works Ltd, was incorporated in April 1898 to manage the works, which were extended and modernized. At its peak, reached in the early 1900s, the factory produced 800 tramcars annually and employed 600–800 men. Shortly after the formation of the Carriage Works, a new factory was built on the west side of Strand Road. This was the property of The English Electric Manufacturing Co Ltd incorporated in November 1899, for making electrical machinery for railways and tramways. Not unnaturally this concern, the Carriage Works and Dick, Kerr co-operated closely and between them were able to offer complete tramway installations. The co-operation led to Dick, Kerr taking over The English Electric Manufacturing Co in 1903. In the following year Dick, Kerr transferred all its electrical work to Preston and concentrated its mechanical products at Kilmarnock. In June 1905, the name of the Carriage Works was changed to the United Electric Car Co Ltd.

III

Meanwhile a liaison on certain electrical engineering contracts was developing between Dick, Kerr and Willans & Robinson Ltd of Rugby. This company was founded in October 1880 at Kingston-upon-Thames, as



Tram manufacture was one of Preston's principal industries. This was the scene during peak production in the car assembly shop of the Carriage Works. (*The English Electric Co Ltd*)

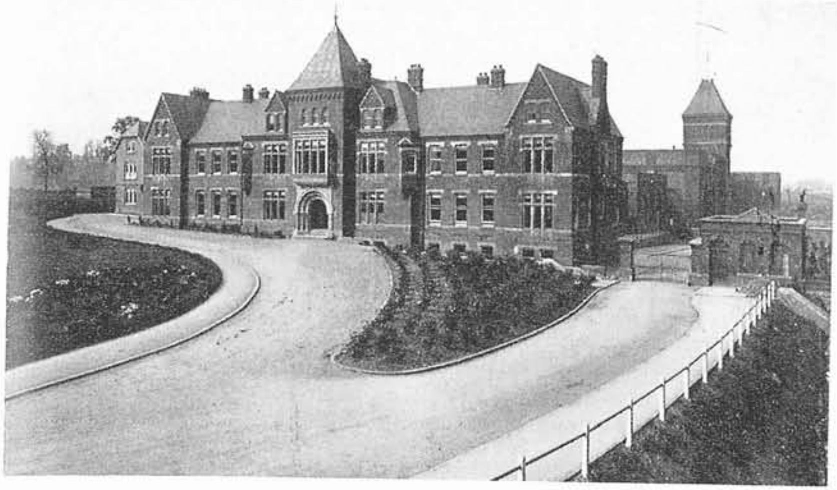
a partnership between Peter William Willans and Mark Heaton Robinson to build Willans' patent three-crank steam engine. Rapid expansion of their company resulted in their acquisition of premises, which became known as the Ferry Works, at Thames Ditton on the river bank opposite Hampton Court. Here, steam engine production was supplemented by a boat-building business.

In 1884, Willans was granted a patent for the central-valve steam engine which was to play the major part in the company's fortunes in the following years. When developed further the engine was found to be particularly suitable for the direct driving of dynamos.

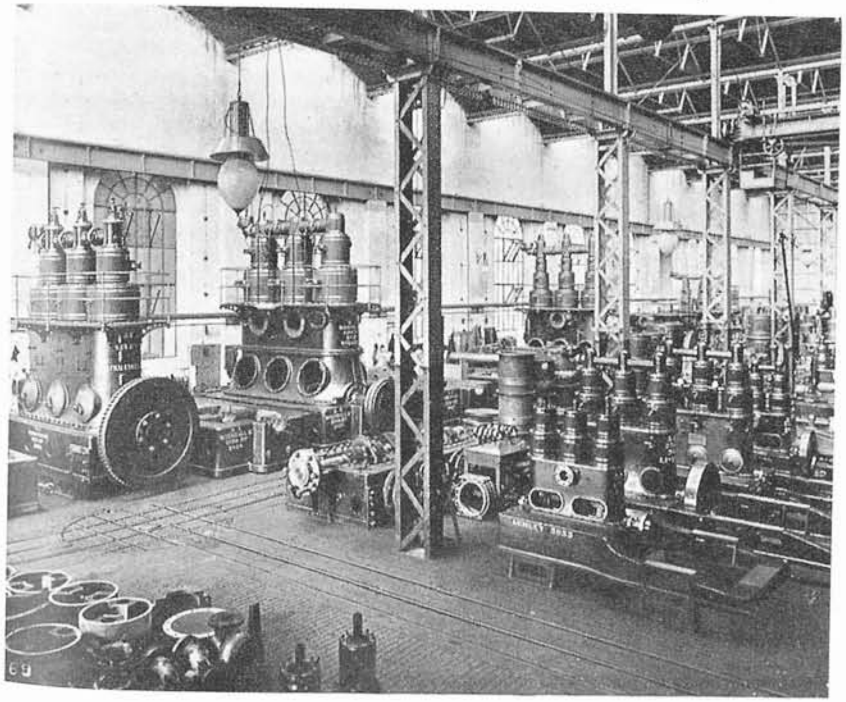
By 1890, it was recognised that work accumulated in connection with more powerful central-valve engines would require a factory larger than the Ferry Works. Subsequently, it was decided to build an entirely new factory at Rugby. It came into operation in 1896 and the Ferry Works was closed down five years later. Meanwhile, in March 1894, Willans & Robinson Ltd had been incorporated as a public company. At the beginning of the century the company was producing steam turbines and oil engines.

IV

In 1903, an electrical generator coupled to a Willans & Robinson central-valve engine was installed at a colliery at Dewsbury in Yorkshire.



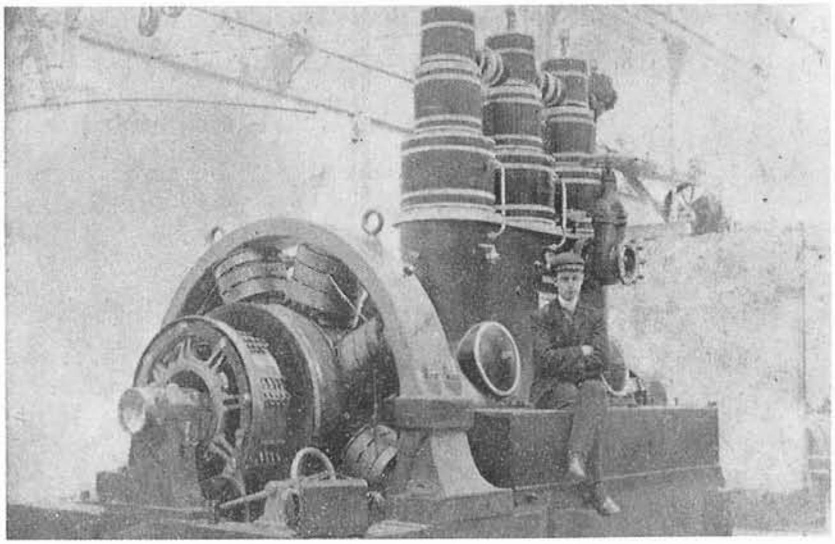
The ornate architectural design of Willans & Robinson Ltd's works at Rugby was influenced by the principal buildings in the town, namely those of Rugby School. The Victoria Works is shown as it appeared in 1900. (*The English Electric Co Ltd*)



Central-valve engine production at Rugby at the turn of the century. (*The English Electric Co Ltd*)

The Phœnix Dynamo Manufacturing Co's works at Leeds Old Road, Bradford, in 1903. (*The English Electric Co Ltd*)

The colliery was owned by Charles Brook Crawshaw and the generator was made by the Phœnix Dynamo Manufacturing Co Ltd, of Bradford, of which Crawshaw was a director and principal shareholder. The earliest reference to the Phœnix Dynamo Co appears in 1895 when it took over the Wray Electrical Engineering Co, of Soho Works, Thornton Road, Bradford. By 1903 the company had moved into the premises at Leeds Old Road, Thornbury, it was to occupy for the rest of its existence. On 11 June of that year, the Phœnix Dynamo Manufacturing Co Ltd was



An early example of collaboration. This Phœnix Dynamo 240 kW generator coupled to a Willans & Robinson central-valve engine was installed in C. B. Crawshaw's colliery at Dewsbury, Yorkshire, in 1903. (*The English Electric Co Ltd*)

incorporated with a capital of £60,000 for the purpose of making low-power, rotating electrical machinery. Three years later the firm was employing about 100 men and had become well known to the textile industry. In September 1907, a man who was to have considerable influence on the company's fortunes joined it as works manager. He was Percy John Pybus.

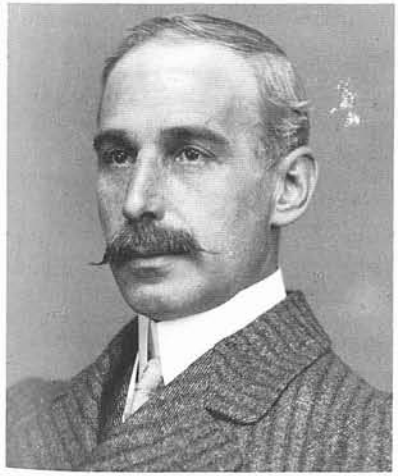
V

In March 1908, the completed Capone helicopter was tested at Norbury Golf Links, which were then alongside the road to Croydon. These and subsequent trials were not successful. The helicopter was despatched to Italy before the end of the year and became Britain's first heavier-than-air aircraft export.

Howard Wright also undertook to install an engine in Moore-Brabazon's Short-built biplane glider. The necessary alterations were made at Brooklands during May 1908, but the end product again was not a success.

Throughout 1907 and 1908, however, Howard Wright was primarily concerned with the mechanical aspects of electricity generating installations. It was while engaged in this work that he met William Oke Manning, an electrical engineer employed by Callender's Cable and Construction Co Ltd. Manning was born at Staines, Middlesex, on 20 October, 1879, the eldest son of Alice Allenby and Herbert Lane Manning. He was educated at St Paul's School, London, and served a general engineering apprenticeship with Callender's Company. It is possible that when he and Wright met they discovered a mutual interest in aviation, because, in December 1908, Manning started work for Howard Wright.

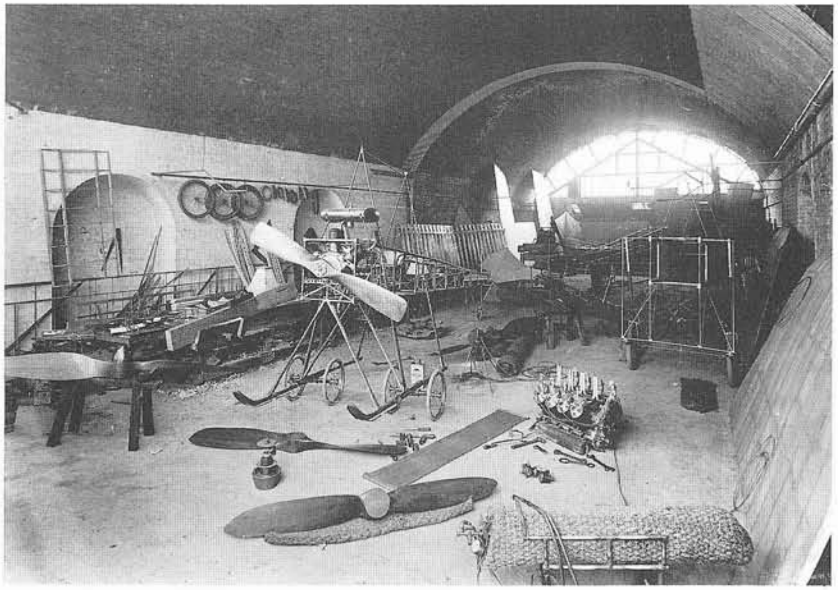
At that time also, Seton-Karr had asked Howard to build him an aircraft on which he could learn to fly. The resultant pusher biplane was the fifth machine to be constructed at Battersea, Howard having



Howard Theophilus Wright, 1867–1944 (left) and William Oke Manning, 1879–1958.

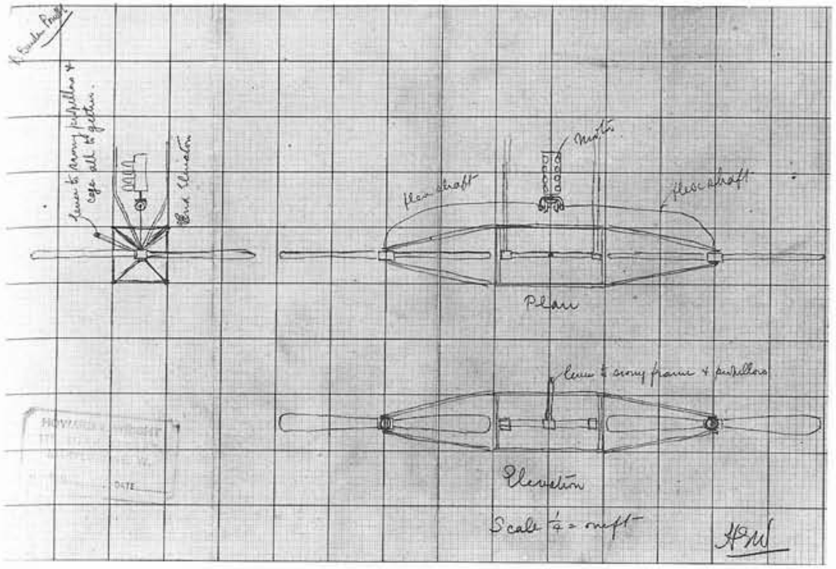
previously made an aeroplane for Horatio Barber and a second helicopter for Capone. Seton-Karr's biplane was finished shortly before the opening of the 1909 Olympia Aero Show where it was exhibited and acclaimed for its outstanding workmanship and several novel features. After the show the biplane was tested at the aerodrome founded by Pemberton-Billing at Fambridge, Essex. It was probably at Fambridge that Manning also taught himself to fly, although he never qualified for the Royal Aero Club's Aviator's Certificate. Howard Wright qualified for his certificate, No. 331, at Sopwith's School of Aviation, Brooklands, on 15 October, 1912.

After a brief sojourn at Fambridge, Howard Wright, in his search for more suitable flying grounds, acquired one of the eighteen sheds built at Eastchurch as well as premises at Larkhill, on Durrington Down, north of Salisbury, and, in 1910, one of the newly-erected sheds at Brooklands.



Howard Wright's workshop at Battersea in January 1910. In the foreground is Boyle's Anzani-powered *Avis* and on the right Lascelles' *Ornis* under construction

This period also saw Howard Wright emerge as one of Britain's foremost aircraft constructors and W.O. Manning established as his chief designer. Not only did they undertake the manufacture of their own designs but also those of private individuals and other companies. By the end of 1909, Howard was employing ten men and his workshop at Battersea was so full of aircraft in various stages of completion that he was regretably refusing additional orders. One of these was a request from Maj B.F.S. Baden-Powell to undertake the construction of a swivelling-propeller mechanism which he (Baden-Powell) intended to install in an aircraft he was currently building at Dagenham. Baden-Powell's request

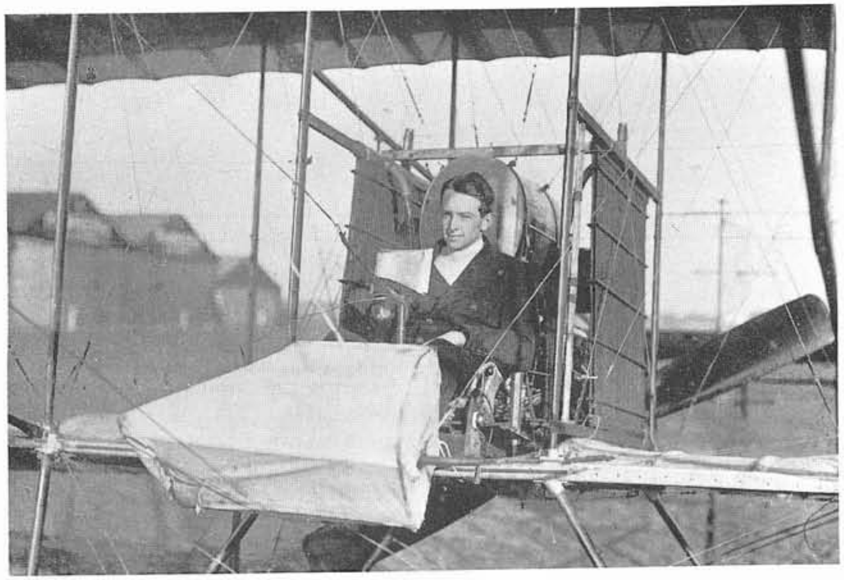


Howard Wright's original drawing of the swivelling propeller mechanism for Maj Baden-Powell's aeroplane.

had coincided with the completion of a third helicopter for Capone. Upon receiving another request from Baden-powell to construct the mechanism, Howard firmly replied on 8 October: 'Under ordinary circumstances I should have been very pleased to construct anything for you but, at present, I am so busy that I find a difficulty in giving the time necessary for drawing up a rather special apparatus and to speak candidly I am a bit afraid of it. If of course you could make the drawings it would not take very long to get it together. I am sorry I do not know anyone who has a large experience in this class of work or I would have been very pleased to recommend someone.' Nevertheless, on Howard's return from Naples, on 8 November, where he had attended the trials of the second helicopter he had built for Capone, a letter from Baden-Powell awaited him. The letter asked Howard's advice as to the cost of testing the engine for driving the swivelling propellers. Howard replied immediately: 'With reference to the test of your engine, as I have previously pointed out, in order to have a test it will be necessary to make a propeller and this will cost £20. There will also be the further cost of setting up the apparatus necessary for the tests. You will remember when you raised this point before I pointed out that perhaps the cheapest way for testing the engine would be in your aeroplane when you have it completed. However, I should be pleased to hear your wishes.' At this juncture, further correspondence on this subject apparently ceased.

In the remaining months of 1909, no less than nine aircraft were completed. Of these, the Anzani-powered *Avis* monoplane built for the Scottish Aeroplane Syndicate was to prove one of the best known of Wright's products. Under construction were six more aircraft of various

The Hon Alan R. Boyle at the controls of the *Avis*. (*W. O. Manning*)



T. O. M. Sopwith seated at the controls of his modified Howard Wright Biplane with which he won the £4,000 Baron de Forest prize for the longest flight into Europe (*B. Robertson*)

forms, which were completed early in the following year.

In 1910, a biplane, which followed conventional two-seat pusher practice of the time, was produced by the then well-established team of

Lieut H. E. Watkins. (*W. O. Manning*)

Wright and Manning. This biplane brought them much publicity from the flights made with it by T.O.M. Sopwith. He had bought the third aircraft of the type and with it won the £4,000 Baron de Forest prize for the longest flight into Europe and, afterwards, made notable flights in attempts to win the British Empire Michelin Cup. The other two biplanes were to be seen flying either at the Royal Aero Club's grounds at Eastchurch piloted by 'Jack Dare', or at Brooklands under the control of Lieut H.E. Watkins. The latter aircraft was, in fact, owned by Lieut E.M. Maitland but, owing to injuries he had received in an accident while flying it, he was unable to fly the biplane and had loaned it to Watkins, a brother officer of the Essex Regiment. Watkins had also entered the Baron de Forest competition but the biplane was wrecked in a gale before he could start. The biplane was repaired and in June 1911 Maitland sold it to the War Office for use by the then recently-formed Air Battalion of the Royal Engineers. At the 1911 Olympia Aero Show, a slightly modified form of the biplane was exhibited. It had been built for Robert Loraine, the Irish actor who had achieved fame in September 1910 with his flight across the Irish Sea in a Farman racing biplane. At least six more 1910-pattern biplanes were built to private order, one of which was exported to New Zealand. The biplane continued to give good service throughout 1912, particularly at Grahame-White's School of Flying at Hendon, where his own Howard Wright biplane was used by many pilots to qualify for their Certificate, among them Marcus D. Manton, who later became chief test pilot to the English Electric Company during the 1920s. An example of the Howard Wright biplane was known to be flying as late as 1913.

In 1911 Howard Wright's business declined. His output for the year was well below what he was capable of producing, and, almost certainly, no

new aircraft were made after June, although he continued to advertise his work at least until the end of November. He was not, apparently, in financial difficulties, a leading aeronautical journal stating at a later date: 'Between 1907 and 1911, some 35 machines were built and Wright's was probably the first aircraft factory in England to run at a profit.' There was also no question of loss of reputation. The demise cannot be explained satisfactorily with the information available at present but the answer might be in the events which were to affect Warwick Wright Ltd in the last months of 1911, although details of any agreements that might have been made have not come to light.

In August, Warwick sold part of his shareholding in Warwick Wright Ltd to the Belgian firm of SA l'Auto Metallurgique, based at Marchienne-au-Pont, and in the following month a special resolution was passed changing the company's name to Metallurgique Ltd. Howard and Walter Wright retained their shareholdings until December, when Howard sold his aircraft interests to the Coventry Ordnance Works.

Warwick Wright appears to have remained in business until just after the outbreak of the 1914–1918 war, when Metallurgique was voluntarily wound-up. Shortly aferwards, Warwick was commissioned as an officer of the Royal Navy Volunteer Reserve, eventually taking command, in 1917, as Lieutenant-Commander, of the Aeroplane Supply Depot at Gûines, near Calais. About this time also, Warwick became one of the first directors of the Kingsbury Aviation Co Ltd. This firm was a subsidiary of the Kingsbury Engineering Co Ltd and appears to have done very little during its existence. During the 1920s, Warwick again set up in business under his own name, as a motor car dealer, and achieved fame as a racing driver at Brooklands. Warwick died in London on 27 May, 1945, at the age of 64.

War

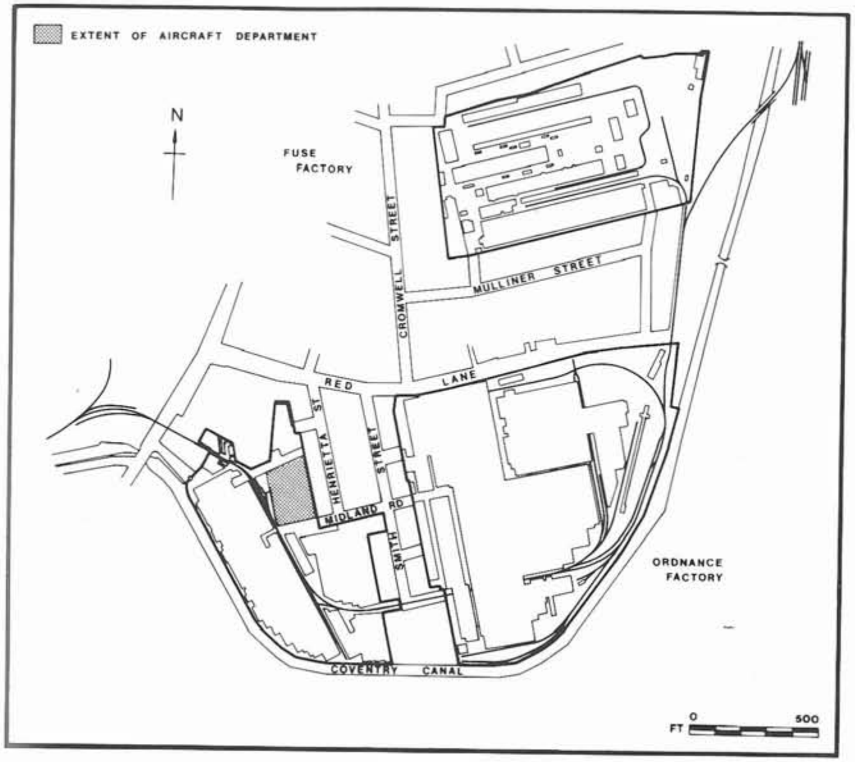
I

The Coventry Ordnance Works had its origin in a company founded at No.10 Gas Street, Birmingham, in 1866, by the brothers, Herbert Hall and Walter Girdwood Mulliner. Their business was coach manufacturers. In April 1895, the firm was registered as a private limited company, of which another brother, Arthur Felton Mulliner, became managing director.* A few years later Mulliners Ltd started manufacturing army vehicles and ordnance stores in Birmingham.

Early in 1902, expansion of the business led Mulliners to acquire a large tract of land for a factory at Coventry. The purchase of a neighbouring factory owned by the Coventry Tube and Metal Co Ltd, brought further expansion and a change in the name of Mulliner's business, in February 1902, to Mulliner-Wigley Co Ltd, ordnance manufacturers. One year later this company was taken over by Chas Cammell & Co Ltd (later Cammell, Laird & Co Ltd) and renamed the Ordnance Works, Coventry.

1905 saw the formation of an autonomous company based on the

* Arthur Mulliner established a coachworks at Northampton about that time and, in 1897, merged his business with that founded in London by his brother Francis. The new firm, which became known as Mulliners Coachworks Ltd, made a few aircraft during 1910 and 1911.



Coventry Ordnance Works, c 1917.

Ordnance Works. Known as the Coventry Ordnance Works Ltd, it was registered on 2 June with a capital of £1 million and offices at Stoney Stanton Road, Coventry. The principal shareholders were Cammell, Laird & Co Ltd and John Brown & Co Ltd, both steel manufacturers with works at Sheffield.

In 1906, COW's share capital was reconstructed to include a third large company, Fairfield Shipbuilding & Engineering Co Ltd, of Govan, near Glasgow. From that time, COW developed rapidly, becoming specialists in the production of naval guns, field artillery and other war material. This work necessitated continuous enlargement of the factory with the result that two separate establishments were brought under the control of COW at Scotstoun, near Glasgow, and at Cliffe, just below Gravesend on the River Thames. At a later date a gunnery range was established at Freiston, near Boston, Lincolnshire.

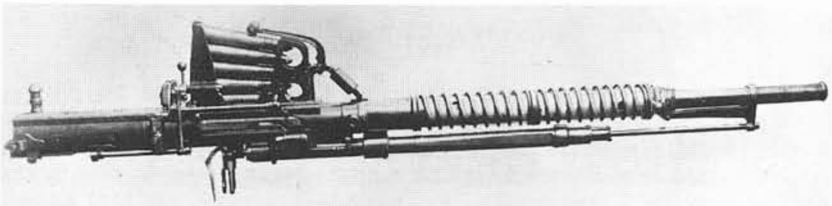
On 6 July, 1909, Herbert Mulliner retired from the board of COW and Rear-Admiral Reginald Hugh Spencer Bacon CVO, DSO, late of the Royal Navy, was elected in his place. Soon afterwards he became COW's managing director.

The *London Opinion* of 20 January, 1912, stated: 'A few weeks ago a hint was given in these columns that certain big engineering firms were

watching for the right time to take up the aeroplane business. The first to take a definite step is the Coventry Ordnance Works, who have taken over Mr Howard Wright's business. The new combination ought to be a strong one. Admiral Bacon, the head of the Coventry concern is one of the keenest and most far-seeing men that either Service has turned out, and he fully realises the important part aeroplanes must play in both naval and military work. Mr Howard Wright is, of course, one of the very first of our pioneer constructors. Mr W.O. Manning, his chief designer, is a genius as a scientific designer, but has hitherto had to waste his ability on designing machines of 'popular' type for customers. Now he will have a chance of turning out some of his really original ideas. The fourth member of the coalition is Mr T.O.M. Sopwith, who will be the new firm's chief pilot.'

The Coventry Ordnance Works' decision to establish an aviation department was due, undoubtedly, to the presence of Rear-Admiral Bacon, who was deeply interested in the military applications of aircraft. Now he had the incentive of the Military Trials, of which the War Office had announced details the year before and which were to be held at Larkhill in August 1912. With the acquisition of Howard Wright's business and the services of Manning as chief designer, Bacon's plans came to fruition. However, the aircraft department was considered to be and remained of secondary importance to COW.

Manning designed two biplanes for COW's entry to the 1912 Military Trials. Their construction was undertaken at Battersea and their testing at Brooklands, where they flew well. At the Trials, however, neither biplane distinguished itself and it was not until after the Trials that Manning was able to investigate the faults which had arisen. He had been abroad during the Trials and Howard Wright had left COW in that month.



The 1½-pounder COW gun specifically designed for aircraft use. An example of the gun is to be seen in the Royal Air Force Museum, Hendon.

On leaving COW, Howard Wright became a director of Hart Aeroplanes and Waterplanes Ltd but relinquished this position before the end of 1912, when he joined J. Samuel White & Co Ltd, of Cowes, as chief aircraft designer and general manager. Howard left Whites in 1917 to become technical advisor to the Air Ministry for the assembly of United States-built Handley Page O/400 bombers. This work was to be done at converted cotton mills at Hollinwood and Shaw on the outskirts of Manchester. During the 1920s, he became an aviation and general engineering consultant using, for a period, offices adjoining Warwick Wright's car showrooms in New Bond Street, London, but this venture proved financially unsuccessful. Howard Wright died in retirement at

Pagham, near Bognor Regis, Sussex, on 12 December, 1944.

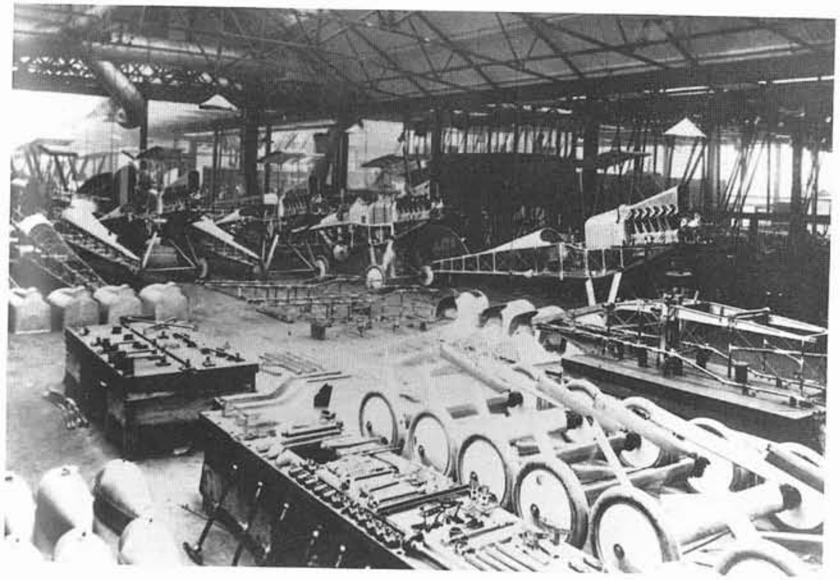
During 1913, COW received an Admiralty contract for one seaplane. This order and, according to a contemporary booklet describing COW's activities, several others 'were attended with a measure of success' and kept the small aircraft department gainfully employed. The later orders were regarded by COW as experimental and were for both land and seaplanes, but of these no records appear to have survived. In 1914 COW discontinued its experimental work in favour of contracts placed with it by the War Office. The first of these was for a small batch of Royal Aircraft Factory-designed B.E.2a biplanes.

II

The outbreak of war in August 1914, brought no radical change in production at any of COW's factories. The main products at Coventry remained field artillery, naval guns and munitions, all of which were produced on a very large scale throughout the war.

By comparison COW's tiny aircraft department was not quite as prepared for quantity production, although it had in hand a War Office contract for twenty-one B.E.8a biplanes destined for service on the Western Front and with home-based training units. The work was slow at first, probably because the department was understaffed and untrained in mass-production techniques, it having made previously only small quantities of B.E.2as, B.E.2bs and B.E.8s. Production for the whole of 1914 totalled about twenty aircraft, deliveries of B.E.8as beginning about May 1915.

On 27 November, 1914, Manning left COW and was commissioned as a



Production of B.E.12as at the Coventry Ordnance Works. (*via L. G. E. Brown*)

Lieutenant of the Royal Navy Volunteer Reserve. He was posted to Port Victoria, the Royal Naval Air Service (RNAS) experimental base on the Isle of Grain, and afterwards to Hendon and the Air Department of the Admiralty. Manning later described his job during that time as 'putting right aircraft that went wrong.' His positions as chief designer and manager of COW's aircraft department were not filled until Arthur Edward Hardcastle Herschel was appointed in May 1915.

1915 proved to be a trying period during which the aircraft department received an order from the War Office for fifty R.E.7 bombers. Progress was very slow as the work was difficult and the special materials required for the R.E.7s tubular-steel fuselage structure were almost unobtainable. By the time the R.E.7s were delivered the type had been withdrawn from the battle zone and they were being used as trainers. Total production for the year was 28 aircraft. The R.E.7 contract was completed in 1916 together with the major part of an order for fifty B.E.12a fighters. New erecting shops were built during the year and the department was considered to be on a production basis by late 1916. Eighty-seven aircraft were completed that year. There followed a series of contracts totalling 450 R.E.8 reconnaissance biplanes, necessitating the building of more erecting shops to accelerate production. Aircraft constructed in 1917 and 1918 numbered 177 and 280 respectively. COW's last two contracts of the war were each for 150 Sopwith Snipe fighters, of which the second was cancelled and none of the first delivered until after the Armistice. The aircraft department was closed early in 1919.

III

War found the Phœnix Dynamo Manufacturing Co with about 300 employees engaged entirely on the production of electrical machinery for coal-mines, textile mills, the Admiralty and the War Office. This situation soon altered when the demand for ammunition became paramount and Phœnix received orders for shells for the army and navy, in addition to the supply of electrical gear.

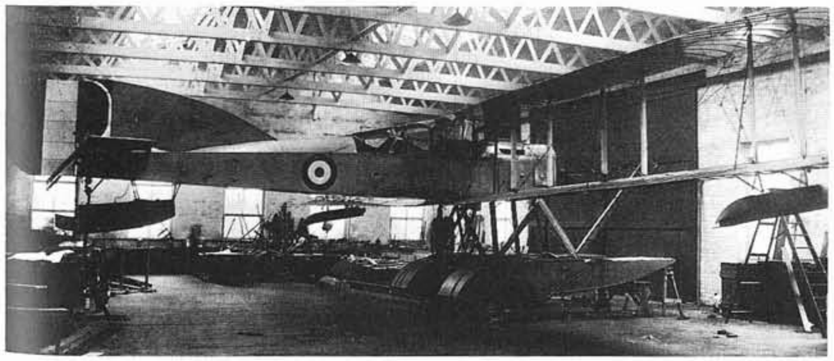
By 1917, Phœnix was employing 4,500 people, a large number of whom were women. P.J. Pybus, who had joined the company as works manager in 1907 and who devoted special attention to the training of unskilled workers and the 'dilution' of labour, was invited by the Prime Minister, Lloyd George, to write an account of the use of female labour in the engineering industry. The result was a book, *Women on munitions of war*, published by the Ministry of Munitions and circulated throughout the country and Empire.

In 1915, Phœnix undertook work far removed from the products it was making and with which it had experience. The work was heralded by a letter from the Ministry of Supply requesting the company to take up aircraft construction on a large scale. There followed an agreement for the production of twelve Short Type 184 patrol seaplanes for the RNAS. On 24 June, the company was advised by Admiralty telegram of the arrival of Short Type 184 No. 843 at the Isle of Grain and asked to send a draughtsman to Sheerness. Pybus immediately sent for Leonard Brown, who had been put in charge of the aircraft drawing office, and after he had been sworn to secrecy gave him instructions on unheaded notepaper.

Brown arrived at Sheerness next day and there met representatives of Mann, Egerton & Co of Norwich, Petters Ltd of Yeovil, Frederick Sage & Co of Peterborough and S.E. Saunders Ltd of East Cowes, who had been similarly notified. They were each to inspect and measure the seaplane and to send back to their company sufficient details for the type's production. This procedure was adopted because Short Brothers had been ordered to sub-contract the seaplane before a complete set of drawings could be prepared. Brown's work was finished by 8 July, when he received further instructions to meet V.S. Gaunt, the Phœnix Dynamo Co's aircraft erection superintendent, and Arthur Todd, who was in charge of the company's fitting and machine shops, at Shorts' works, Rochester, where they were to study the construction of the seaplane. Soon afterwards, Brown and Todd returned to Bradford to supervise the final preparations for production. Victor Gaunt remained at Rochester, until 28 July to gather further information, assisted by his wife, who acted as secretary, and then they too returned to Bradford.

The aircraft department then employed about 50 men (this number was to increase to 250 over a period of nine months), none of whom had had previous experience of aircraft work, and had consequently to be trained although they were all skilled men. Construction of the first Short Type 184 was, therefore, slow and it was November before the first fuselage structural skeleton was ready for fitting-out. The immediate need for extra labour led to Christopher Pratt & Sons Ltd and the Thornton Engineering Co Ltd, both of Bradford, undertaking work on behalf of the Phœnix Dynamo Co. This was the beginning of an association that was to last for the duration of hostilities. Pratts and Thorntons produced complete sub-assemblies and Phœnix did the final assembly, inspection and delivery of the aircraft, besides making components.

The first Phœnix-built Short Type 184 was despatched on 12 January, 1916, to RNAS Great Yarmouth where it was successfully test flown later in the month by Ronald Kemp, Shorts' test pilot. The last was completed the following June. Meanwhile, in March, the company received an Admiralty contract for ten Short Bombers. Again a lack of information necessitated Brown's closely inspecting the Bomber before manufacture,



The first Phœnix-built Short Type 184, 8368, being assembled at Bradford in January 1916. (*via L. G. E. Brown*)

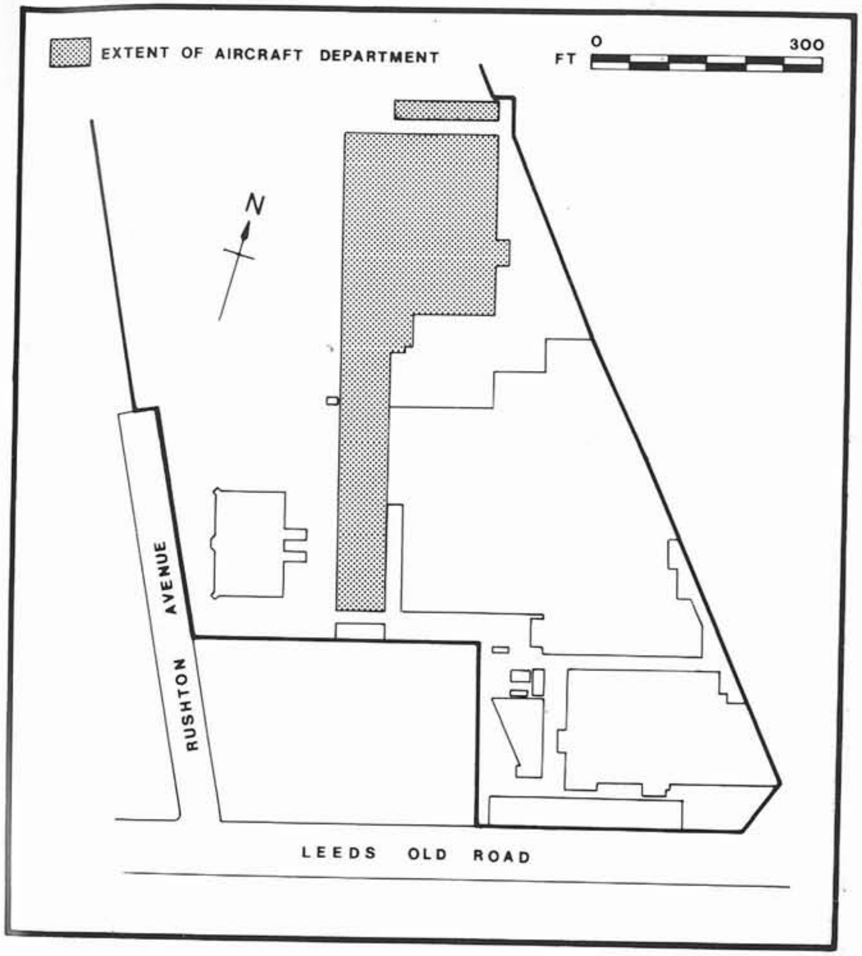
this time at Short's aerodrome at Eastchurch. Production proceeded smoothly until held up in June when an order was given to increase the length of the Bomber's fuselage. The first Bomber was completed on 31 July, 1916, but was wrecked on its initial flight three days later, the pilot, Clifford B. Prodger, founder member of the Prodger-Isaac Aviation Co, escaping serious injury. At the end of August, the Admiralty cancelled the last four machines of the contract. The remainder, including the first which was rebuilt, were delivered and saw active service.

In the meantime, Brown had been appointed manager of the aircraft department. He did not hold this position long, however, as he was taken seriously ill with appendicitis. On his return to work, a few months later, he was made chief draughtsman, Todd having been appointed manager in his absence. Todd was succeeded, in 1917, by Capt John C. Crawshaw, late of the RFC and son of the company's chairman, and Gaunt became his assistant.

Lieut Stronach was the Admiralty's technical representative at Bradford until about September 1916, when Lieut W.O. Manning replaced him. At that time the company was seriously considering forming an aircraft design team to exploit the facilities it had available and, apparently, Pybus made the most of an opportunity when he learnt of Manning's background. Manning was asked if he would be willing to become the company's chief designer, to which he agreed providing he could secure his release from the Admiralty. This was accomplished on 5 October, 1916.

On taking up his appointment, Manning was given a small office adjoining that of Todd's among the 'front' or executive offices overlooking Leeds Old Road. There he worked alone as designer, aerodynamicist and performance engineer, calling upon Brown and a small number of his staff to develop his ideas and to produce the required drawings. These draughtsmen were themselves capable designers with a working knowledge of aircraft stresses. All the designs Manning produced for Phœnix used the statistical data he had collected from official test reports during his early days of office and had continued to amass while he was with the company. The data included wing areas, weight breakdowns, performance analyses and engine characteristics, from which Manning correlated parameters such as wing loading, power loading, payload/power ratio with speed and rate of climb, and structure weight and payload as percentages of all-up weight. Stress, performance and stability calculations were generally based on the confidential and secret reports and memoranda published by the Air Department of the Admiralty (later merged with the technical department of the War Office to become the Air Board) and the Advisory Committee for Aeronautics which co-ordinated the research done by the National Physical Laboratory and the Royal Aircraft Factory.

Manning's design notes show that he invariably started work on an aircraft project by compiling a list of weights of items that made up its equipment and payload and which included the engine. He next produced a sketch of the aircraft and estimated its wing area based on wing loadings obtained by comparison with existing designs. This information was passed to the draughtsmen for preliminary scheming. From their drawings, an estimate was made of the weights of the various structural components to obtain the machine's loaded weight. Next, Manning checked the wing and power loading and, if these values were found to be



Phœnix Dynamo Manufacturing Co Ltd's Works, c 1918.

unacceptable, recalculated the wing area or modified the aircraft's layout. Later in his career, he assumed the structural weight minus that of the wing to be 40 per cent of the loaded weight. Wing area was then determined from the choice of wing loading and wing weight was based on statistical analysis. For the purpose of calculation, Manning initially considered the wings to be of equal span and equal chord (the majority of his designs were biplanes, although he investigated tri-, quadru- and even quintoplane layouts) but once he had satisfied himself of the wing area he nearly always chose an upper wing of higher aspect ratio than the lower, this arrangement being more aerodynamically efficient.

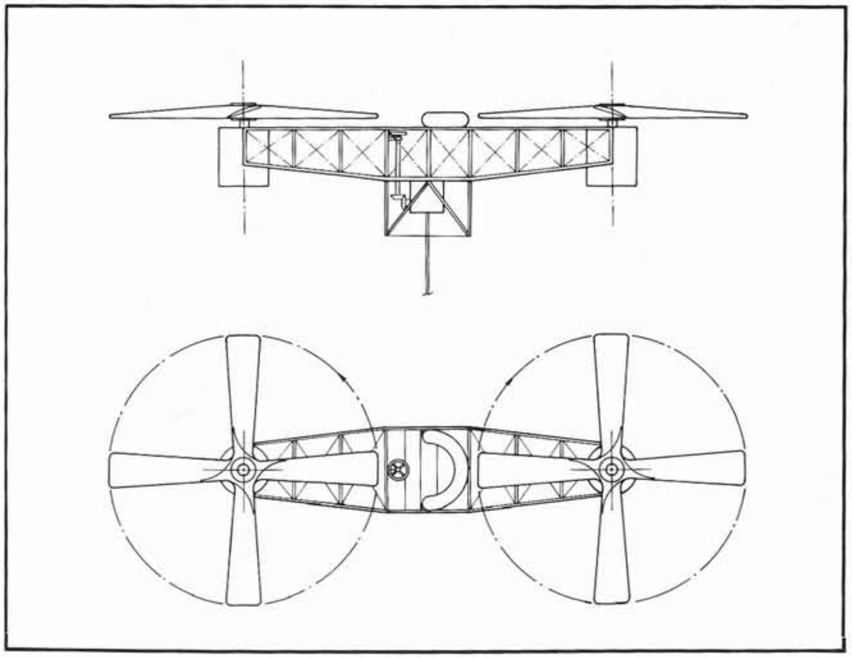
His next step was to consider the wing's aerodynamic characteristics. First, he would select an aerofoil section and correct its coefficients of lift and drag and lift/drag ratio for biplane effect, since the data generally

related to a monoplane of fixed aspect ratio tested at constant wind-tunnel speed. Then he applied corrections for aspect ratio and Reynolds' Number where they differed from the envisaged full-scale machine. Another check was then made on wing area using the maximum lift coefficient and the specified stalling speed.

At this stage, the layout of the aircraft would be sufficiently 'frozen' for Manning to estimate its drag using empirically derived data. Afterwards, the aircraft's performance was calculated with respect to speed at various altitudes, rate of climb and service ceiling. Range was usually specified in terms of endurance and was governed by the quantity of fuel.

This work was followed by detail stressing of the major structural components. Manning's notes indicate that he concerned himself with the spars, interplane-struts and bracing-wires only. The absence of fuselage stress calculations suggests that these were undertaken, possibly, by the draughtsmen, who were also responsible for the design of small detail parts. The brevity of Manning's work, which took a few months only, may be sharply contrasted with the number of years taken today to reach this point in the design of an aircraft.

In the years to come, Manning was to be widely regarded by his contemporaries as a brilliant designer with a natural intuitive flair for his craft. He was completely dedicated to his work, very often neglecting his own well-being for the sake of it, and meticulous in everything he undertook. However, his approach to his work was direct and simple and manifested itself in the elegance of his designs.

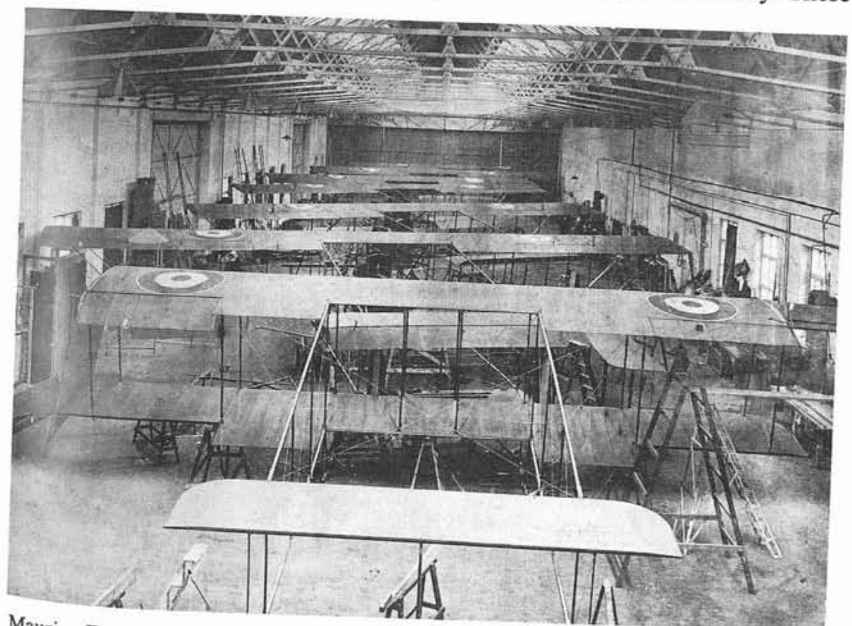


Phœnix helicopter observation platform.

The first aircraft he considered at Bradford was a twin-float, two-seat, single-engined pusher seaplane of orthodox layout intended for anti-submarine patrol duties. It was given the designation P.1, an abbreviation of Phœnix Type No.1. Although its design was considered in detail, the seaplane was not built.

The Phœnix P.1 was not the company's first aircraft project. The first was a twin-rotor helicopter observation platform designed by Pybus and embodied in patent 109,672 applied for on 30 September, 1916. The contra-rotating rotors were directly coupled to squirrel cage induction motors with aluminium windings, mounted at the extremities of a box-girder structure, which carried the observer and his parachute. Power for the motors was supplied from a ground or ship-based generator by an electric aluminium cable that served also as a tether. Pybus sought in the smallness of the device a means of reducing the vulnerability of observation platforms, then carried aloft by large unwieldy balloons and kites.

Shortly before Manning joined Phœnix, the company received a contract for twenty Maurice Farman Longhorn training biplanes for the RNAS. Again a lack of drawings necessitated measuring an existing machine and this was done using Longhorn No.8927 built by the Brush Electrical Engineering Co at Loughborough. The work was done by Brown, E. Wigglesworth and another colleague. The first machine was ready for delivery on 16 December, 1916, and was despatched by rail to RNAS Eastchurch. A few more Longhorns were sent by rail, to Eastchurch and Chingford, but the majority were flown from a small field adjoining the works to RNAS Killingholme on the Humber Estuary. These



Maurice Farman Longhorn production at Bradford, January 1917. (*via L. G. E. Brown*)

flights were shared by John Lankester Parker, then attached to the Prodger-Isaac Aviation Co and later to become test pilot to Short Bros, and Rowland Ding, the Blackburn Aircraft Co's test pilot. Deliveries were made throughout the appalling winter of 1917 and were completed on 13 March. Meanwhile the company had received a further order for ten Longhorns, which was completed by April 1917.

In April also Phœnix produced two Armstrong Whitworth F.K.10 Quadruplanes for the RNAS. Much was expected from the novel arrangement of these aeroplanes but Service trials showed their performance to be poor.

By April, too, the company was busily engaged in the production of thirty Short Type 184 Dover seaplanes, the first of which was test flown by Clifford Prodger at Brough on 3 June. The use of Blackburn's flight sheds at Brough on the Humber Estuary for the final erection of the seaplanes resulted from the Government commandeering the site as a base for No.2 Marine Acceptance Depot and a request from Phœnix to the Admiralty for permission to use its facilities. Delivery of this batch of seaplanes was completed in November but by then Phœnix was building another twenty, which were finished about February 1918.

This increase in output and the possibility of receiving even larger orders brought about reorganization and expansion of the company's production facilities at Bradford. The existing long construction and erecting shed was extended in length to almost triple its original floor area. In addition, new erecting and dope shops, together with a drawing office and sewing room, were built to one side of the construction shed. The extensions were

View of construction and erecting shed at Bradford in January 1918. Felixstowe F.3 hulls being fitted-out. (*via L. G. E. Brown*)

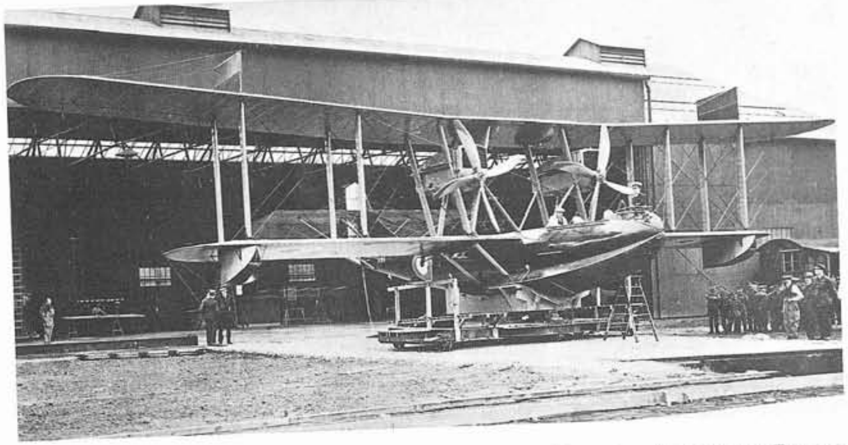
completed in October 1917, at which time the company employed about 900 men and women on aircraft construction alone.

The first of the anticipated orders came late in 1917 with the receipt of a contract for fifty Felixstowe F.3 flying-boats to be built at the rate of one a week. There followed contracts totalling 120 aircraft, for both the F.3 and its development the F.5. Of these, however, at least fifty F.5s were cancelled shortly after the end of the war. The first of the Phœnix-built F.3s was test flown at Brough in February 1918 and subsequently delivered to the Experimental Establishment at the Isle of Grain. The last machine to be completed was despatched to store at about the end of the year. Those machines delivered saw active service in home waters in their role of anti-submarine patrol, although a few were allocated for experimental work.

The start of flying-boat construction at Bradford in 1917 coincided with the start of similar work at Dick, Kerr's factory at Preston. Possibly, the Admiralty ordered the two companies to co-operate during preparations for production because from that time there existed a liaison between them in all aspects of the work concerning the flying-boats. It is believed that initially an interchange of drawings took place and that Phœnix advised Dick, Kerr on production techniques.

November 1917 saw the emergence of the Phœnix design team under Manning and the begining of a change in the company's role within the aircraft industry. This new phase came into being with the award of a contract for two experimental flying-boats of the same type, for which Phœnix had responsibility for the design of their flight structure and assembly. The hulls were to be supplied by May, Harden & May Ltd. The type became the fifth design to be considered by Manning and consequently was designated P.5. It was later named Cork. The first flight of the P.5 took place at Brough on 4 August, 1918. Subsequent testing of the aircraft revealed a flying-boat superior in performance to the Felixstowe F.3 it was intended to replace, but the Cork was not put into production.

Components of the automatic pilot made by the Phœnix Dynamo Co and believed fitted to Felixstowe F.3 N4409 (c/n 208) for trials. The main attitude-sensing devices were mercury-filled circular tubes which acted as switches for electrically-operated compressed-air flying controls. (*via L. G. E. Brown*)



The Phœnix Cork N86 on the apron outside the hangar at Brough on the Humber Estuary, August 1918. (*via L. G. E. Brown*)

With the completion of the order for the Cork early in 1919 came the closure of the aviation department, although Phœnix was still under contract to produce one of two Fairey Atalanta flying-boats, for which the company had taken delivery of the Gosport Aviation-built hull early in 1919. This aircraft and its sister ordered from Dick, Kerr were the subjects of further co-operation between the two companies. In this instance Dick, Kerr supplied drawings of the aero-structure for both machines. Only the Dick, Kerr aircraft was completed however.

The closure of the department had little affect on Manning's work. He continued with the design he had begun at the end of the war, a civil transport flying-boat of 100,000 lb loaded weight named the Eclectic. He also considered the possibility of modifying a Cork for an attempt at the £10,000 prize offered by the *Daily Mail* for the first direct transatlantic flight. These proposals came to nothing, however, and were among the last he projected as chief designer to the Phœnix Dynamo Co.

IV

Willans & Robinson, too, progressively switched to armament production during the first months of war and was soon fulfilling the numerous and varied orders placed by the Government and the Services, as well as meeting urgent home and overseas needs for power plant.

The company also undertook the manufacture of aero-engines, this work starting early in 1914 when a decision was taken to obtain a licence from The Dudbridge Iron Works Ltd, the British licensees, for the manufacture of the Salmson water-cooled radial engine produced in France under the patents of its designers Canton and Unné. In July 1914, a specialist engineer from the Société des Moteurs Salmson, at Billancourt on the western outskirts of Paris, was seconded to Willans & Robinson for a period of six months to facilitate production in the shortest time possible. On his arrival at Rugby he met H.B. Adams, a 22 year-old engineer who

had been selected from the Diesel Engine Department to work with him and eventually assume his responsibilities when he returned to France. The first Salmson engine completed at Rugby was built to the original pattern rated at 130 hp. It was tested to destruction by continuous running and found to have certain faults requiring a number of modifications. Subsequent tests proved satisfactory and production to War Office and Admiralty contracts began early in 1915. Contracts were for both the seven-cylinder single-row 130 hp and later fourteen-cylinder two-row 200 hp models, and totalled about 350 engines. Production of these engines ceased during 1916. An example of a 130 hp Salmson made by Willans & Robinson (serial No.36) may be seen today among the aeronautical exhibits at the Science Museum in London. There followed orders for about 200 Sunbeam aero-engines, which were completed during 1917 and 1918.

Meanwhile in 1916, Dick, Kerr & Co acquired a controlling interest in Willans & Robinson. No immediate changes were made in the directorate and management at Rugby and the company continued to operate under its own name until 1918, when its incorporation in the Dick, Kerr organization was completed.

V

At the declaration of war, Dick, Kerr & Co had in hand several major civil and electrical engineering contracts. This work, however, continued uninterrupted while the company reorganized its factories for the production of war material.

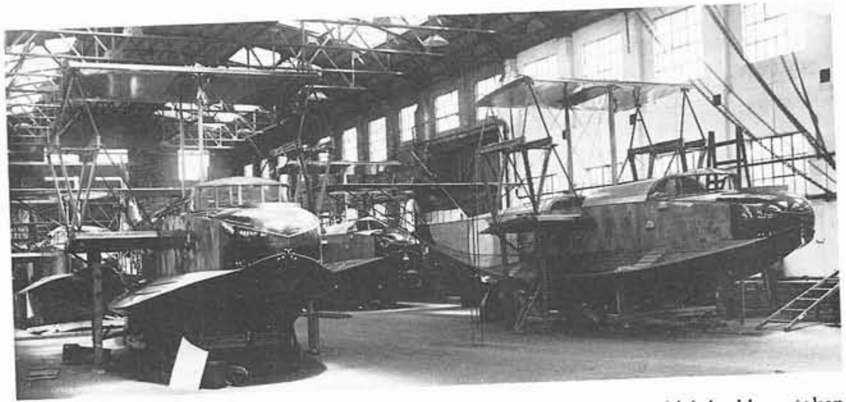
Initial wartime contracts, placed by the War Office and the Admiralty, were for shells, production of which was to form a large part of the company's output. In addition to these orders, the company made and refurbished parts for guns and howitzers, and did similar work for other manufacturers both at home and abroad.

By the end of the war the number of Dick, Kerr employees had quadrupled to over 8,000 and all business had been dropped apart from some orders received mainly for tramcars and generating plant. Traction and electrical business generally was geared to the immediate needs of war.

Meanwhile in 1916 Dick, Kerr had expanded its organization by, in addition to the controlling interest in Willans & Robinson, the purchase of the AEG Electric Company, a subsidiary of AEG of Berlin, from the Controller of Enemy Property. In the following year the company gained control of the United Electric Car Co, its neighbour at Preston, when it bought the larger part of that company's shares.

The United Electric Car Co employed 1,200 people during the war and before being taken over was engaged in the production of army equipment and shells, besides tramcar bodies ordered as required by Dick, Kerr. Soon after the take-over, late in 1917, the company started making and assembling components for the flight-structure of Felixstowe F.3 flying-boats, pending the arrival of hulls built by contractors in other parts of the country. The contract for the flying-boats was placed with Dick, Kerr and was for 50 machines. At about the same time, work began on expansion of the company's premises to facilitate an increase in production.

South Shields, approximately 100 miles northeast of Preston, too, was



Felixstowe F.3 production at the United Electric Car Works, Preston, which had been taken over by Dick, Kerr & Co late in 1917. This photograph was taken about July 1918. (*via W. Shorrock*)

the scene of preparations for aircraft manufacture. There a working party led by James Barton, Dick, Kerr's chief foreman, equipped two large hangars for final assembly and erection. The hangars were among a group of equally large sheds built on the shore at the base of the cliffs overlooking the harbour. All buildings faced onto a very wide and long apron and slipway leading to the water. Possibly, Dick, Kerr chose the site because of the strong connections it had with the area dating back to 1894 and to use the existing facilities of the RNAS station based there for patrol operations with Short 184s. The hangars were ready by 3 February, 1918.

The first Dick, Kerr-built F.3 arrived there a few days later, the journey via Skipton, Harrogate, Thirsk, Osmotherley, Stockton-on-Tees and Sunderland taking three days. At Sunderland the police were given advance notice of the arrival of the flying-boat, which had been dismantled for transport, the Boulton & Paul-built hull covered with tarpaulin forming one lorry load and the aero-structure contained in a scenery van forming another, and they accordingly cleared the road through the town. The steam-driven lorries were part of the fleet belonging to H. Viney & Co Ltd, haulage contractors of Strand Road, Preston (adjacent to the United Electric Car Works), and Manchester. This company was to convey all the flying-boats to South Shields. On arrival the aircraft was quickly reassembled and, on 12 February, put through engine tests. Eight days later it was flown for the first time by an RNAS pilot, Capt Newton, and in honour of the occasion the F.3 was unofficially named *Pauline* after his wife. The flying-boat was not delivered, however, it being wrecked at its mooring in the harbour by a sudden storm in the early hours of 26 February. No mishap befell the second F.3 which was completed two days later and delivered to RNAS Houton in the Orkneys on 14 March. The thirty-fifth and last machine to be tested at South Shields flew on 28 February, 1919. The remaining fifteen aircraft of the contract and six of those that had flown were put into store at South Shields which had by then become a Marine Acceptance Depot. In December 1919 the sheds were handed over completely to the newly-founded Royal Air Force.

Dick, Kerr received a second contract for fifty F.3s but this was

The seaplane and flying-boat sheds overlooking South Shields harbour. (*J. Barton*)

amended to include thirty-two F.5s. Construction of this batch began in September 1918 and was done entirely at Preston but in the event only eleven F.3s and two F.5s were delivered, the order being terminated because of the end of the war. These and incomplete machines which could be used as spares were put into store. Dick, Kerr's third contract, for fifty F.5Ls, was cancelled.

Towards the end of the war, the Government requisitioned a piece of land beside the Ribble Estuary at Lytham from the estate of Squire Clifton. There they built two large hangars and a slipway to the estuary. It is believed that the site was used by Dick, Kerr for the final erection of the last Felixstowe flying-boats made by the company.

In the last weeks of war, also, the company took delivery of the large hull built by May, Harden & May for the Fairey-designed Atalanta. Design of the aero-structure for this machine, and that of its sister to be assembled by the Phœnix Dynamo Co, started at Preston in April 1918. Final assembly of the Atalanta was done in one of the Lytham hangars. The flying-boat was not completed until 1921, however, and another two years were to elapse before its first flight at the MAEE, Isle of Grain.

Amalgamation
I

After the signing of the Armistice on 11 November, 1918, came sudden and drastic reductions in the volume of war work. Consequently, factories and labour forces were then too large for the requirements of prewar business. Production capacity had greatly increased but there was no comparable increase in demand. Traditional markets, particularly those overseas, were lost and had to be regained. Retrenchment and consolidation became inevitable.

Dick, Kerr & Co, however, surprisingly expanded its interests by entering into an alliance with the Coventry Ordnance Works so that it could use the very large engineering works at Coventry. Further, Dick, Kerr established companies in France and Japan to exploit its manufacturing rights in regard to railway and tramway equipment. By the end of 1918 the company was rapidly gaining orders for its traditional products.

By comparison the Phœnix Dynamo Co was finding difficulty adjusting to conditions of peace. The company had been almost wholly occupied with the production of war material and, therefore, had been unable to maintain completely its home market. Moreover, it had specialised in electrical machinery and, consequently, could not readily divert labour to other non-electrical products more likely to be in demand. Retraction to its prewar size became the only course of action and the labour force was reduced to 450 people.

Men and women who had been designing and making aircraft, not only at Bradford but throughout the country, were the concern of a small committee chaired by P.J. Pybus. The committee was one of several bodies specially appointed by the Minister of Reconstruction to advise on the many aspects of reallocating labour and resettling industry to peacetime conditions. Recommendations made by the committee included temporary diversification of products using the skills, materials and equipment available. This was put into practice at Bradford where aircraft workers were occupied making domestic and office furniture.

Both companies not only recognised the economic necessity of immediate reorganization but also that they stood a far better chance of survival in an uncertain future by combining their knowledge, resources and markets, and, perhaps, operating as one company. Since they had previously co-operated successfully in fulfilling numerous joint contracts, this idea appeared to be a logical step. Exploratory discussions began during 1918 and quickly came to fruition after the Armistice but not before the Coventry Ordnance Works, Willans & Robinson and the United Electric Car Co had been included in the negotiations.

II

Amalgamation came on 14 December, 1918, with the incorporation of The English Electric Co Ltd. It was achieved by the new company acquiring in turn all the shares of the Coventry Ordnance Works and the Phœnix Dynamo Co, and exchanging shares with 90 per cent of Dick, Kerr's shareholders, and because the last company also controlled Willans & Robinson and the United Electric Car Co, they, too, were brought into the organization. At the time, English Electric stated that it would take over external business management and interfere as little as possible with the internal organization of the firms concerned. The assets of each company were leased to English Electric. Resolutions for the voluntary winding-up of the individual firms, with the exception of Dick, Kerr, were not passed immediately and a number of years were to elapse before all were finally wound-up as trading companies.

The English Electric Co was registered as a private company with a capital of £5 million. Its registered office was at 3 Abchurch Yard, London, E.C. The objects of the company were: to carry on the business of electrical, mechanical, hydraulic and general engineers and contractors; to manufacture and deal in electric, galvanic and magnetic apparatus and appliances; to supply light, heat, sound and power; to manufacture, repair and deal in vehicles, cycles, engines, airships, aeroplanes, armour plates, gun mountings, explosives, etc, and to deal in petrol and other volatile oils and spirits, lubricants, metallic compounds and chemicals, etc. The

company's board of directors was a strong one, having close connections with shipbuilding and railways. Its chairman was Sir Charles Ellis, who was also a director of COW, John Brown & Co and the Great Eastern Railway.

III

The first two years in the life of the new company were spent consolidating its organization and resuming normal activities at each of its factories. The latter was achieved by applying the policy of 'devoting each works to the manufacture of that class of machinery for which by reason of its layout and past history it is best adapted.' This meant generally that the factories continued with their traditional products.

The exception to this policy was the Coventry Ordnance Works, the largest of all the factories taken over by English Electric. It was considered ideally suitable for the manufacture of large electrical machinery and it was converted accordingly. However, the works was never satisfactorily utilised despite attempts at diversifying its products. Consequently, a decision was taken in 1923 to close the main factory and to sell it if a favourable offer was received.

During this period the Rugby factory continued to make turbines but concentrated on the smaller sizes and from 1920 onwards English Electric manufactured its own designs only. That year also saw an important new phase when the Fullagar opposed-piston oil engine was put into production, successfully developed and within two years being sold world-wide for electricity generating purposes.

At Bradford, the range of products remained much as it had been except that motors and dynamos of increasingly higher power were being added continually to the company's prospectus. Progress was made, too, towards using the former aircraft shops in a more productive capacity. After the war they had been rented out partly as a wool store and partly as a bus depot. Now the long assembly shed was allocated to the manufacture of industrial electric trucks and the smaller aircraft shops to woodworking, pattern making and storage of electrical goods. The use to which the assembly shed had been put, however, was still evident in the forms of the incomplete Fairey Atalanta and the engine test rigs occupying its northern end.

At Preston a number of changes were made in the organization of the factories, but they did not affect the normal range of products made there and the factories continued to specialise in electric traction and ancillary equipment.

English Electric's formative years ended in 1920 with the purchase of Siemens Bros Dynamo Works at Stafford. Before that the factory produced a wide range of electrical machinery. After its purchase, English Electric arranged for the extremes of the range of products made there to be transferred to Bradford and Coventry, leaving the Siemens Works to make only medium-sized electrical machinery.

Besides consolidating its home interests, English Electric pursued a vigorous policy of expansion abroad. This resulted in the renewal of former agencies and associations established by its forbears and the setting-up of new offices to represent its own interests. By 1920, the

company had branch offices or agencies in most parts of the world. Throughout the next few years the company also sought to improve further its economic position. This it did, despite a general depression in trade, and as a result was able to declare fairly substantial profits.

IV

All business at home and abroad was directed from English Electric's more imposing head office at Queen's House to where the company had moved from Abchurch Yard in about September 1919. This seven-storeyed building faced onto Kingsway and, at the rear, overlooked Lincoln's Inn Fields. It was to here in early 1920 that W.O. Manning transferred his office from Bradford after becoming English Electric's chief aircraft designer. He worked there alone and was allotted space in the corner of a large office shared by other employees, an arrangement which he, apparently, did not consider ideal. After persistent requests he eventually obtained his own office. Manning was concerned initially with the refinement of the last design undertaken for the Phœnix Dynamo Co, namely the Eclectic, a very large passenger-carrying flying-boat. This, however, was interspersed with new designs for civil and military flying-boats and seaplanes, and the conversion of existing Phœnix designs from military to civil roles. The resultant civil variants were widely publicised in English Electric's brochure of 1919–1920, *Transport by Aircraft*. From that time until June 1921, a period of about thirteen months, it must be assumed that Manning considered no new projects, if his design notes are believed to be a continuous record of his work. His apparent inactivity has yet to be satisfactorily explained. In June 1921 he began a study which was to lead eventually to the construction of the English Electric Ayr, an experimental Fleet reconnaissance flying-boat.

V

In August 1921, the company began to show more serious interest in its aircraft activities, possibly as a result of the influence of Pybus, who had been appointed managing director that year. Manning at that time had devised and patented a novel form of biplane flying-boat which used the lower wings as sponsons to provide lateral stability whilst afloat. The design, designated M.1, was evolved to meet an official requirement for a Fleet gunnery and spotting aircraft. Wind-tunnel and water-tank tests were conducted on a small scale model. The results of these and additional design work were sufficiently promising to encourage the Air Ministry to order two experimental prototypes. At this stage the flying-boat had undergone small changes and had been redesignated M.3 Ayr.

Soon after starting work on the M.1, Manning was authorised to build up a small design team. The first member to join him was Henry Knowler, who was appointed as his assistant. Knowler had been introduced to Manning by a friend, and had had by then considerable experience having joined the aviation department of Vickers Ltd in 1914 and worked there throughout the war under its chief designer, Rex Pierson. Next to join the team was John S.L. Oswald, a former colleague of Manning's at Bradford, followed by J. Raymond Farrow, and two draughtsmen named Mason and Gray.

The M.1 and its variants fully occupied the six men until the summer of 1922, when this work was temporarily halted in order to produce drawings for the installation of Napier Lions in the Phœnix Cork Mk II, which was redesignated Mk III after they had been fitted. The re-engined Cork afterwards accompanied the Flying Boat Development Flight on its cruise from the Isle of Grain to the Scilly Isles in August of that year. The success of the Cork on that occasion, despite its loss on the return flight to Grain, led Manning to consider its development. He received additional encouragement in this in the form of an official requirement for a coastal patrol and anti-submarine flying-boat, which had just been issued. Work on the new aircraft began in earnest in September and by the end of the year was sufficiently far advanced for an attempt to be made to interest the Air Ministry in the project. Official acceptance came in January 1923 with the signing of a contract for one prototype. From that time the design was known as the Kingston.

In October 1922, there occurred an event which was to provide Manning with inspiration for a project that was to receive much publicity. The occasion was a gliding competition held at Itford on the Sussex Downs, which he attended in an official capacity. There his thoughts turned to flying using a minimum of power. On returning to his office at Queen's House, he set to work on a small single-seat monoplane in which he proposed to fit a 3 hp ABC motor-cycle engine. The design did not take long to complete and was eventually to take shape in the form of the Wren.

With three promising new projects on the drawing boards at Queen's House there came the need for production facilities and a decision was

Staff of English Electric's aircraft department at Preston in 1924. In the front row, from left to right, are: Robertson (chief buyer), Manton (chief test pilot), Williams (chief draughtsman), Gaunt (assistant works manager), Gibson Knight (works manager), Alexander (works superintendent), Jackman (foreman woodworkers). (*The English Electric Co Ltd*)

taken before the end of 1922 to re-establish an aircraft department at the Dick, Kerr Works, Preston. The site chosen within the factory was that which had been used during the 1914–1918 war. The reopening of the department resulted in many ex-employees of Dick, Kerr and the United Electric Car Co, who had remained with English Electric, returning to their former wartime trade and in the transfer from Bradford of a number of men who had had similar experience. Among those from Bradford were Eric Gibson Knight, formerly an AID inspector, V.S. Gaunt and Edward Jackman. Gibson Knight was appointed manager of the aircraft department. Gaunt, in fact, was recalled from the Coventry Ordnance Works where he had become head of the progress department. He was made chief draughtsman and had about six men under him. Jackman became foreman in charge of all woodworkers except those who made the hulls. His counterpart in charge of fitters was Jack Day from Preston. The hull builders came under John Alexander, who had previously worked for Wm Fife & Sons on the Clyde. During its existence, the department employed at its peak about 300 men and women.

In general, details of the aircraft designed at Queen's House were sent to the drawing office at Preston in the form of general arrangement and major assembly drawings accompanied by copious notes concerning important features. Detailing of the various components and decisions on methods of manufacture were left to those in charge at Preston. Manning and Knowler visited there only when the occasion demanded, otherwise keeping in touch by letter, memoranda or telephone. Liaison was made on a more personal basis when, in 1925, R.L. Howard-Flanders joined the aircraft department and was employed on that task.

The first English Electric aircraft flew on 5 April, 1923, when, in Manning's presence, the Wren piloted by Sqn Ldr Maurice Wright made three short flights from Ashton Park, Preston. Three days later, it made its first protracted flight, this time from the sands at Lytham. Subsequent flights were considered so successful that a decision was taken to build two more Wrens for the *Daily Mail* Light Aeroplane Competition to be held at Lympne in October, and, before the end of the month, they were under construction. The Wrens were demonstrated to good account during the event at Lympne with the result that Flt Lt W.H. Longton, who flew one

The hangar at Lytham used by English Electric from 1923 to 1926 for the construction and assembly of its flying-boats. The slipway can be seen on the right. (*The English Electric Co Ltd*)

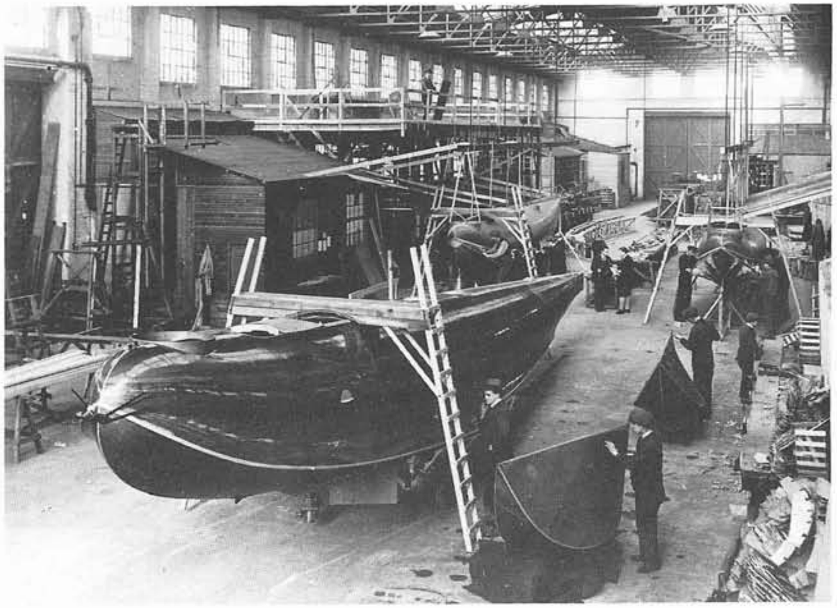
Maj H. G. Brackley, Air Superintendent of Imperial Airways, whose services were secured by English Electric to flight-test the prototype Kingston and the second and third Kingston Mk Is. (*via British Aerospace*)

of them, and A.H. James, who flew an ANEC monoplane, shared the prize for the best fuel consumption achieved during the competition. Coincidentally, among the adjudicators was Howard Wright. Much later, components from these two Wrens were used to restore one of them to flight worthy condition and preservation by the Shuttleworth Trust.

In the summer of 1923, Henry Knowler left the company to become chief designer of S.E. Saunders Ltd, afterwards Saunders-Roe Ltd. He later became director in chief of design and, on the retirement of Sir Arthur Gouge in 1953, technical director. Whilst there Knowler was responsible for many designs, beginning with the Valkyrie and culminating with the Princess. He was to be joined in 1926 by Raymond Farrow who became Saro's chief draughtsman.

As the Kingston approached completion towards the end of 1923, the need to prepare a base for flight testing became of paramount importance. The site and shed the company had previously used at Lytham for the assembly of the Fairey Atalanta was still vacant, although the property had reverted to its original owner. On 1 November, English Electric acquired a 996-year lease on this and shortly afterwards began preparing the site which had lain derelict for two years.

The Kingston was completed at Preston and transported by road to the Lytham flight shed for final erection in April 1924. On 22 May, the Kingston, piloted by Maj H.G. Brackley, was launched onto the Ribble Estuary for taxi-ing trials and afterwards its first flight, but on the point of take-off was irrepairably damaged by flotsam which ripped open the hull bottom. The crew escaped injury. Later, further contracts for six Kingstons were given to the company. These were completed between the autumn of 1924 and March 1926.



The Linton Hope hulls of the prototype Kingston (in the foreground) and Ayrs under construction at English Electric's Dick, Kerr Works, Preston, in June 1923. (*The English Electric Co Ltd*)

In February 1925, the first of the Ayr prototypes made its début at Lytham. Tests were conducted in the following month, the pilot on these occasions being Marcus Manton, who had been recently appointed the company's chief test pilot and inspector. He had joined English Electric very early in 1924 as superintendent of the aircraft department. Trials were unsuccessful and the Ayr never flew.

On the morning of 16 March, 1926, the last Kingston built at Lytham took off from the Ribble Estuary for Felixstowe. Later that morning the company announced the shutting-down of the aircraft department. The closure was not totally unexpected. For some time there had been little work for the department with no prospect of obtaining more orders, and, towards the end of 1925, dismissal of employees had begun. Moreover, the cuts outlined in the Air Force Estimates meant that English Electric's aircraft department, which was very small compared with other well-established aircraft manufacturers, could not hope to compete economically for the meagre orders that would become available. Besides the department was relatively unimportant, the company had many other more profitable interests.

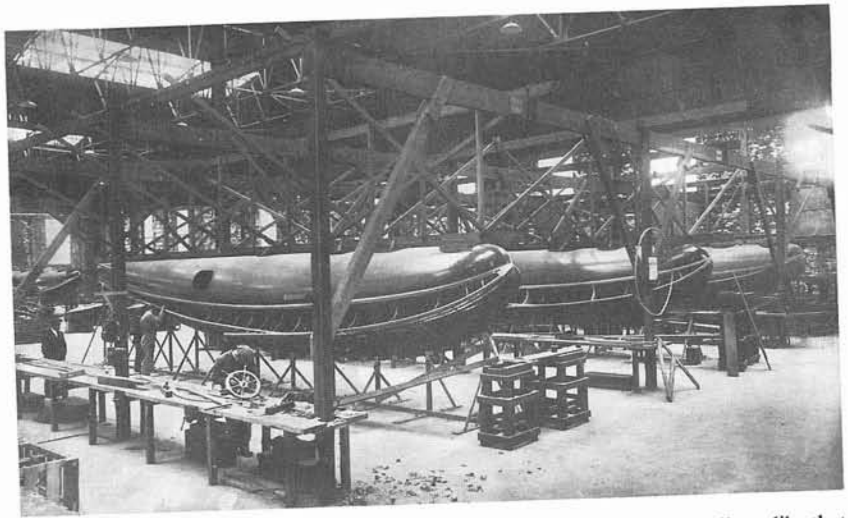
At Lytham, the immediate concern was to avert large-scale unemployment in a local industry that had been widely expected to flourish. The Mayor of Lytham St Annes, Alderman Lightwood, promptly telegraphed Sir Samuel Hoare, the Air Minister, and also sent a letter reiterating the situation. However, by 3 o'clock in the afternoon he had received a reply by telegram: 'Decision as to impossibility of placing any

From late 1924 to early 1926 flight-testing of English Electric aircraft was the responsibility of Marcus Manton (centre), Alan Calder (left) and C. J. Blackburn. (*The English Electric Co Ltd*)

orders this year with English Electric Company was taken with the utmost reluctance and after full consideration of all relevant factors, including those you mention. The Secretary of State regrets therefore, that the proposed deputation from the Town Council can serve no useful purpose—Private Secretary.' The aircraft works was completely closed by the second week in April.

VI

April 1926 also saw the dispersal of the design team at Queen's House. Manning was made redundant. From about 1927 to 1929, he became a consultant employed by FIAT in Italy, where he was involved in the design of a number of racing seaplanes including the C.29. On returning to this country he took a similar position with Simmonds Aircraft Ltd, of Weston, Southampton. During the next few years, Manning's interest in aircraft appears to have been self-inspired, one of the designs he considered being a high-speed high-altitude bomber. Manning also wrote a number of technical books and articles for aeronautical magazines. From 1935 to



Construction of the Kingston Mk I hulls was undertaken at Lytham. These hulls, unlike that of the prototype's, were built completely in the upright position. (*via V. S. Gaunt*)

1939 he was in charge of the Airworthiness Department of the British Gliding Association. In 1940 he joined the staff at RAE, Farnborough, where he was engaged for the following two years writing and editing technical papers. During the next four years he was employed by Flight Refuelling Ltd (he was a co-inventor of the now well-known probe-mounted refuelling valve). Manning finally retired in 1946 but still retained a general interest in the aircraft industry. He died at Farnham, Surrey, on 2 March, 1958.

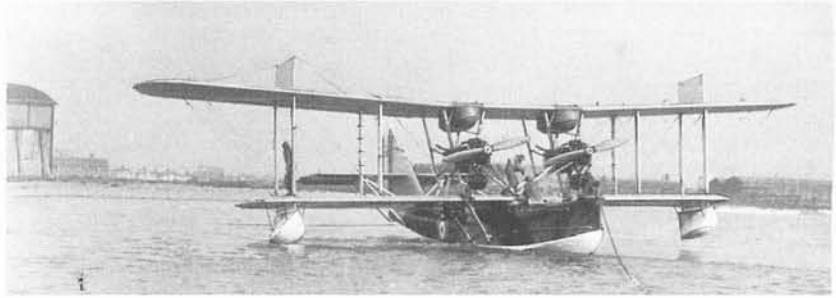
Of others: Marcus Manton became Service liaison officer with Armstrong Whitworth Aircraft from 1939 to 1945 and before retiring in 1946 held an appointment with Hawker Siddeley; R.L. Howard-Flanders set up in business to design and produce portable wireless receivers, from 1929 onwards held various secretarial posts and in 1939, the year he died, joined the design staff of the Bristol Aeroplane Co; V.S. Gaunt took charge of Westland Aircraft's experimental department from 1926 to 1936, having under him at one time W.E.W. Petter, and afterwards joined Blackburn Aircraft.

Of the premises formerly occupied by the aircraft department: the site at Preston was rapidly converted for the assembly of railway locomotives and that at Lytham remained vacant until demolished in 1932 to make way for an extension to Cooksons Bakery. The bakery, built in 1930, used the other hangar (previously leased by the Parkstone Film Co) and the roof of this may still be seen today.

Interim

I

The company's business during the next few years reflected world-wide trade conditions. Losses were declared at each successive annual general



The Kingston Mk III N9713 being prepared for its flight from Lytham to Felixstowe, on 16 April, 1926. (*The English Electric Co Ltd*)

meeting of the shareholders, despite attempts to economise by reorganizing the factories. The crisis came in 1930 when English Electric was forced to reduce its capital. Financial reorganization enabled the firm to liquidate its bank overdrafts and provided a substantial sum for re-equipment. In that year also the Coventry Ordnance Works was sold and the part of the Dick, Kerr Works dealing with heavy engineering items was closed. The partial closure of the Preston factory resulted in the transfer of its products to Bradford, Rugby and Stafford.

In 1933, George H. Nelson, who had been elected to the board three years earlier, was appointed chairman and managing director. Under his energetic leadership the company flourished and within two years there was a distinct improvement in the volume of business. By the end of 1936 the Preston factory had reopened and had started to make diesel locomotives. It also took over the domestic appliance department which had been formed earlier at Bradford. The rate of production doubled during 1936 and the company entered the new year with its largest ever order book, 32 per cent of which was filled with exports. In 1938, the rearmament programme began to have its effect on the company's activities. The chairman was to comment later: 'As a result of our personal observations on the Continent, we felt that circumstances had arisen which made it the duty of this Company to place its accumulated experience and engineering organization at the disposal of the Government to help in the vital purpose of expediting the defence programme.'

II

In the late 1920s and early 1930s British defence policies were based on the assumption 'that at any given date there will be no major war for ten years.' As a result, expenditure on military equipment for the Armed Forces, during the period up to 1934, averaged only £23 million per annum, the RAF share being about a third of this. Officially, between 1923 and 1934, the RAF was being expanded, but nevertheless by the end of 1933, its strength was still ten squadrons below minimum recognised establishment. New military aircraft, which were often below international standards, were allotted to existing units to replace aircraft of 1914–1918 war vintage, instead of being used to form new squadrons. As a result of the low level of aircraft orders, companies in the industry which relied

solely on aircraft work were struggling to remain solvent. A further consequence was that standards of design were low and manufacturing facilities inadequate. In fact, the industry was only kept alive by the Air Ministry policy of sharing out the meagre orders available among all the remaining aircraft manufacturers.

However, early in the 1930s political events in Europe and the Far East caused the official views on defence to change, and in 1932 the 'no major war for ten years' doctrine was abandoned and the British Government decided that some of the deficiencies in the Armed Forces should be made good over a five year period. Planning started in 1934, and by early 1936 the first rearmament programme had been adopted. This was, however, limited by lack of funds to producing aircraft adequate for peace-time operation only, and in any case the run-down aircraft industry had no new designs available for large-scale production.

A new programme, introduced in February 1936 and known as Scheme F, was intended to produce 8,000 aircraft of more modern design. These included such types as the Spitfire, Hurricane, Battle, Blenheim, Whitley, Hampden and Wellington, which were to be delivered to the RAF over a three-year period.

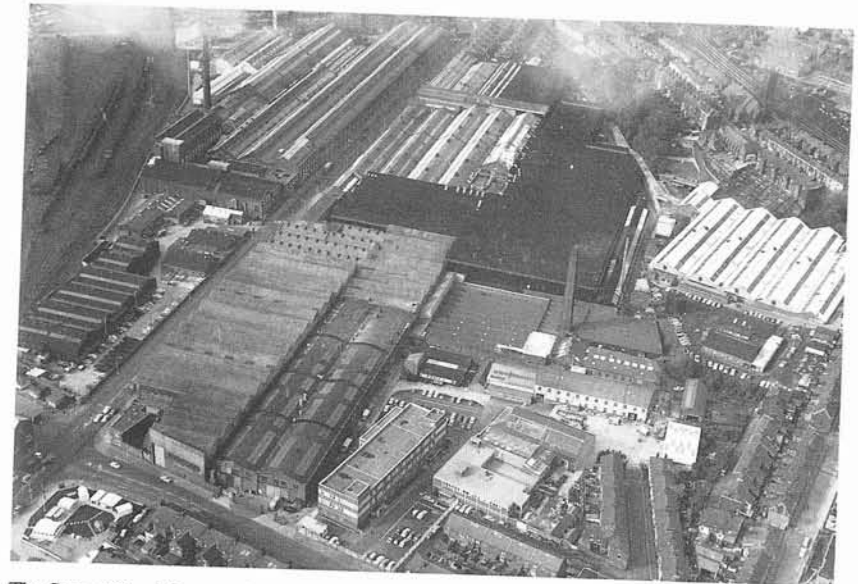
By the spring of 1938, Scheme F was recognised as being inadequate. Deliveries were well behind schedule, and most of the important modern types of aircraft were still not in production. Further, it was apparent that the industry was becoming saturated. Consequently, with the introduction, in April 1938, of Scheme L calling for 12,000 aircraft to be built in two years, sub-contracting was resumed. It was in this capacity that the English Electric Company re-entered the aircraft field.

Wartime Production

I

The companies, which in 1938 undertook sub-contract work, became known as the 'shadow' aircraft industry. This 'shadow' industry was intended only to expand manufacturing capacity, and was not to undertake design work. The sub-contracting policy envisaged the involvement of two types of sub-contractor. Most numerous would be a large number of small and medium sized firms, which would make detail parts and sub-assemblies, mainly to be supplied to companies within the 'family' of established aircraft manufacturers, who would undertake final assembly and flight testing. The second type of sub-contractor would be a small number of large companies which would build and flight test complete aircraft.

Those companies chosen to be major sub-contractors building complete aircraft had to fulfil certain requirements. Basically they had to have a proven record of efficient large-scale production of high-quality, precision engineering products. This condition implied that the companies would have competent and flexible management organizations. Of lesser importance were the requirements for factories, plant, and manpower. Provided that a satisfactory nucleus of skilled and experienced workpeople existed, a large labour force could quickly be recruited and trained, whilst factories and plant were similarly capable of rapid modification and expansion as necessary.



The Strand Road factory. Strand Road runs from bottom left to top centre. All the industrial buildings in the photograph are part of the factory, which has changed little since the completion of wartime extensions. The only postwar additions are the two modern blocks in the centre foreground (*British Aerospace*)

It was considered that the electrical and motor industries were the most suitable sources of major sub-contractors, English Electric and Metro-Vickers being the electrical firms selected, whilst Austin, Nuffield and Rootes were chosen from the motor industry. These five companies formed the nucleus of the shadow airframe industry.

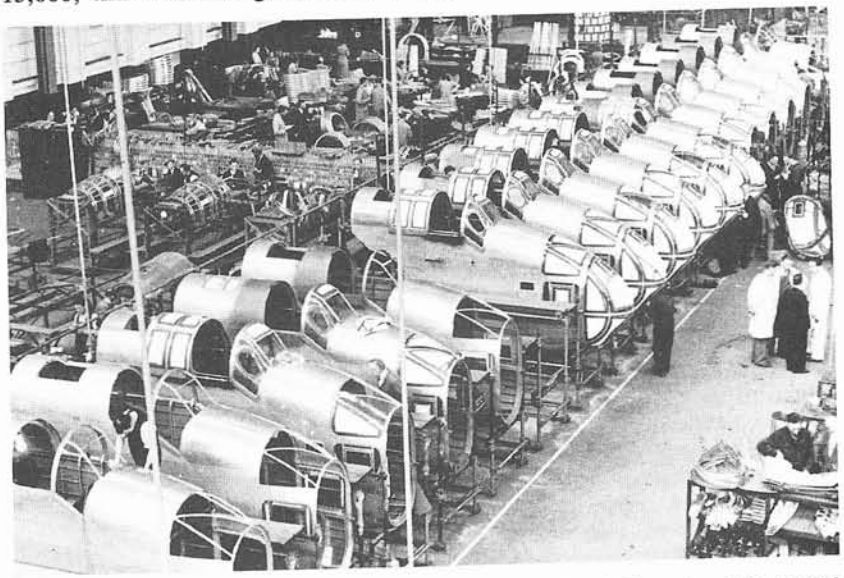
It was originally intended that these firms should be limited to undertaking final assembly and flight testing only, with airframe component manufacture itself being the subject of further sub-contracts. However, English Electric chose to be responsible for the manufacture of the complete airframe, in addition to all assembly and flight-test work. All the production work was to be centred on the factory at Strand Road, Preston. Although large-scale manufacture was intended, the factory capacity and manpower available at Preston in 1938 were very inadequate, and the company did not have an aerodrome. The first priorities became, therefore, the conversion and extension of the Strand Road factory, and the preparation of an aerodrome suitable for flight testing. The nature and scope of this construction work was to be determined by the choice of the type of aircraft to be built.

II

In mid-1938 the Air Ministry decided that English Electric should build the Handley Page Hampden medium bomber. Formal contact between Handley Page and English Electric was established in June 1938 and in the following month English Electric's chairman, G.H. (later Sir George)

Nelson, accompanied by the Preston works manager, Arthur Sheffield, visited the Handley Page works to see the building of the Hampdens, which were just beginning to come off the assembly line. Close collaboration soon became established between the two companies, the process being helped by the transfer to English Electric of a small number of specialists from Handley Page. A little later, F.D. Crowe of Handley Page was appointed to be that company's representative at English Electric's Preston factory. The wartime association between Crowe and English Electric was to lead to his joining the company at the end of the war, to become a leading member of the company's postwar design team.

On 3 August English Electric was informed that the first Hampden contract to be placed with the company would be for 75 aircraft, although orders would eventually total many hundreds. Twelve days after being notified of the first contract, the company received verbal agreement from the Air Ministry for work to start on modifying the East Works of the Preston factory preparatory to aircraft manufacture. These extensions, started in November 1938, were to house the erection of major airframe assemblies. Factory floor space before being increased was about 250,000 sq ft. By the end of 1942 when works extensions and flight-test hangars were complete, the total floor area in use for manufacture and assembly was over 2,000,000 sq ft. Following the start of work on the first extension schemes, approval was received in February 1939 for a second series, although construction of these did not start until after the completion of the first series. Manpower at the Strand Road factory in mid-1938, before the start of expansion, was under 1,000. Recruitment of extra labour began that year, and by the end of 1942 the total labour force numbered over 13,000, this level being maintained until 1945.



Handley Page Hampden front fuselage assembly at Strand Road, November 1941. (*British Aerospace*)

By April 1939 the only outstanding part of the expansion programme was the flight-test aerodrome. The site selected was at Samlesbury, six miles east of the Preston factory and had not previously been developed as an aerodrome. It was on rising ground in open country, roughly mid-way between Preston and Blackburn, enabling labour to be recruited from both towns, a practice which continues to the present time. Construction of the first hangar was started on 10 April, 1939, and completed in October 1939 (it was the only one available for final assembly of the early production Hampdens), construction of two tarmac runways starting in August 1939.

In February 1939, while planning for Hampden production was gathering momentum, English Electric received instructions from the Air Ministry to prepare for the production of 100 Halifax heavy bombers. At that time the Halifax was in the very early stages of development, and the prototype was not to fly for another eight months. The first contract for Halifaxes was received in April 1940, and called for 200 aircraft.

During 1939 steady progress was made towards the initial flight of the first Hampden, and further steps were taken to increase production capacity at Strand Road. The most notable events of the year were the completion of the first series of extensions to the Strand Road factory, the start of work on further large-scale extensions, and the opening in November of the first hangar at Samlesbury. In addition, it was decided that the West Works of the Strand Road factory should be used to provide capacity for the expected orders for Halifax production. The extensions begun during the year included the Aircraft Design and Experimental Building, which was to be used initially for Halifax production development.

The third large series of extensions to the Strand Road factory was approved in late December 1939, and work began early in January 1940. These extensions affected the main machine shop, which took the name Wellfield from the road that ran alongside. The expansion of manufacturing capacity continued with the completion of a large new detail parts shop in April 1940. In the following month, work started on a second hangar at Samlesbury, which was to be several times larger than the first and was intended to be used eventually for Halifax final assembly.

Major assemblies for the first Hampden were transferred from the Strand Road factory to Samlesbury for final assembly on the last day of 1939. Soon afterwards the tarmac runways were completed, five months after the start of construction, and six weeks before the first aircraft was ready to fly. The first Hampden flew on 22 February, 1940, and was delivered in March 1940. The elapsed time from receipt of contract to first flight was fourteen months. In this period, not only was manufacture of a relatively complex aircraft introduced into the Preston factory, with all the new plant and tooling that was required, but also the works itself was substantially modified and extended, the flight-test aerodrome built and six new employees taken on for each original one.

Until the summer of 1940 English Electric had been engaged in the manufacture of new aircraft only, but in July a contract was received for salvage, breakdown and repair of damaged Hampdens. Salvaged parts such as wings, tail surfaces and fuselage sections were sometimes used in the production of new aircraft, and proved valuable at a time when material and other shortages were liable to cause delays.

Samlesbury airfield, with the main group of hangars in the foreground. Although the photograph was taken in about 1970, the appearance of the airfield is basically unchanged from wartime. (*British Aerospace*)

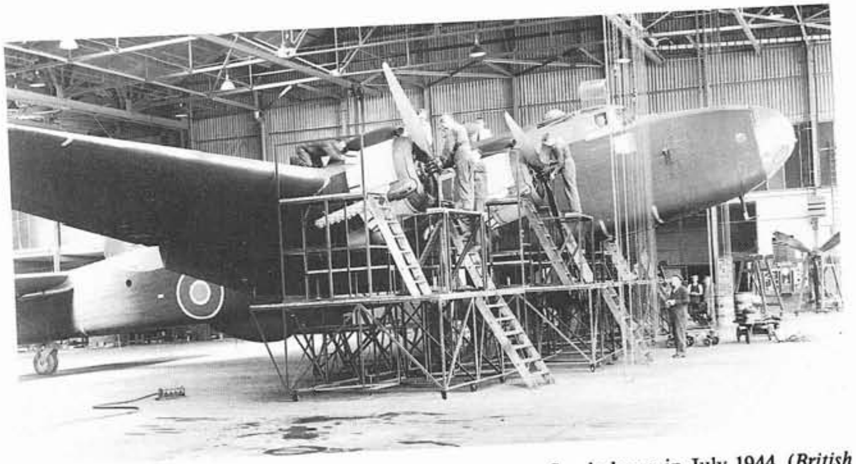
In August plans for two more hangars at Samlesbury were approved, to be used initially for Hampden repair and modification work. At Strand Road the extensions to the Wellfield machine shop were completed late in 1940, as were several large new airframe erecting shops. The latter were intended for Halifax assembly work, which started early in 1941. By the end of 1940 all the important building schemes at Strand Road were complete.

III

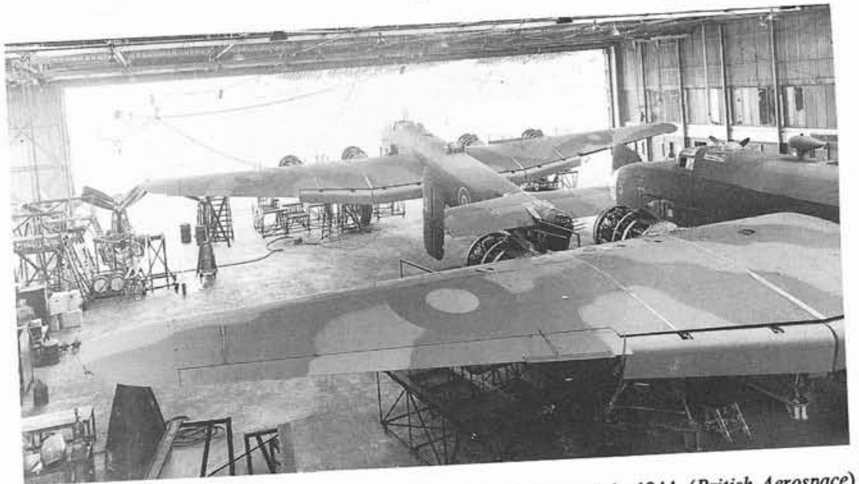
During the planning of the expansion of the aircraft industry, consideration was given to the probable effects of air attacks on aircraft factories. Plans for dispersal were considered, but were not executed before 1940 in order to avoid any disruption in the expansion programme. However, emphasis was placed on building new factories away from the vulnerable areas of South East England and the Midlands. The development of the English Electric Preston factory for aircraft work complied with this principle, since North West England was considered to be a relatively safe area. However, in the summer of 1940 enemy air attacks on aircraft factories caused the Ministry of Aircraft Production (MAP) to apply the dispersal policy. The extent to which production of large aircraft could be scattered was distinctly limited, since particularly large factory buildings were required. The main effort was, therefore, directed towards dispersing manufacture of detail parts and small assemblies into smaller premises near the main factory. The English Electric Preston factory was intended to build large heavy bombers, so that there was no reasonable possibility of dispersing the bulk of the production work. Additionally, the factory was in an area considered to be comparatively safe, so that large-scale dispersion was not particularly necessary. However, from January 1941 a number of premises were requisitioned by the MAP for use by English Electric. These premises were all in Preston, and initially four sites

The reconnaissance photograph of Preston taken by the Luftwaffe in August 1940. The docks area and English Electric's Strand Road factory are defined by heavy outlines. The factory is to the northeast of the docks area. Below the photograph is an analysis of the features and buildings of the docks area and the factory. (*via British Aerospace*)

were occupied. The largest was a part of the factory owned by Courtaulds Ltd, which was used for the manufacture of self-sealing fuel and oil tanks, and also for the production of engine cowlings. Austin House, a motor agent's premises, was used for the making of upholstery for aircrew seating. Part of the Preston Corporation bus garages at Deepdale was used for storage of raw materials and aero-engines. Also used for storage was the Victoria Warehouse, which was in Strand Road near the factory. Later in 1941 the premises of the Canal Foundry were taken over for the manufacture of drop stampings, and among several other buildings used at

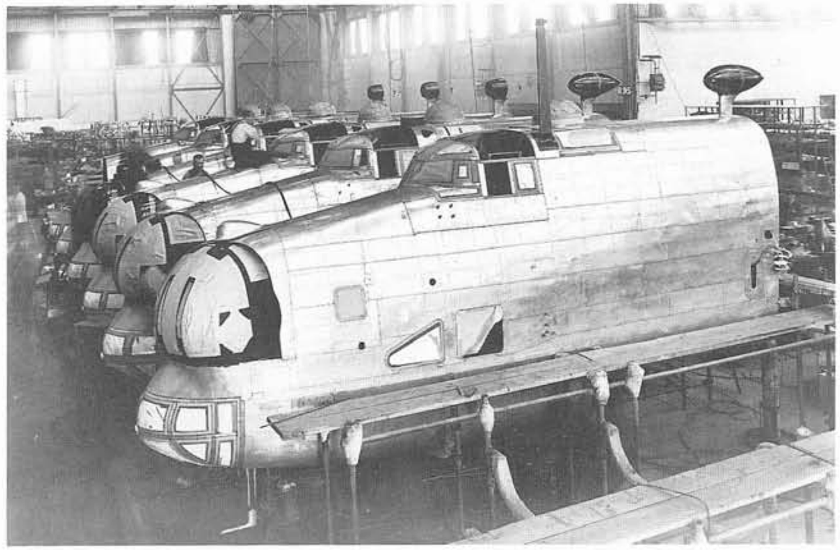


Halifax Mk III MZ868 almost complete in No.2 hangar, Samlesbury, in July 1944. (*British Aerospace*)



The front of the Halifax Mk III assembly line at Samlesbury, July 1944. (*British Aerospace*)

later periods of the war was Preston Prison. Although Preston was regarded as being in a relatively safe region, the Luftwaffe did undertake aerial reconnaissance of the area. After the war, English Electric discovered that on 29 August, 1940, aerial photographs of its Preston works had been taken, along with pictures of the nearby Preston Docks area. On a print of one of these photographs, which was obtained after the war, the boundaries of the English Electric factory and of the dock estate had been accurately marked by German aerial intelligence. With the photograph was an analysis of the buildings of the English Electric factory, accurately interpreting both the type and area of each building. However, the factory was identified as an 'Electrical Machine Works, English Electric Co Ltd', so it would appear that German intelligence was unaware



Completed front fuselages for Halifax Mk II Series 1s at Strand Road in August 1942. (*British Aerospace*)

of the aircraft work which had been in progress for over two years. This was perhaps why the works was never bombed. The airfield at Samlesbury was also never damaged, although on one occasion incendiary bombs fell on and near the aerodrome.

IV

By 1941 aircraft production was fully established at Preston, and in the first half of the year output of the Hampden reached its peak. Production in both March and April was 50 aircraft, but after April the production rate was steadily reduced, owing to the approaching introduction of the Halifax. For this reason, in April the MAP cancelled the last 130 aircraft of the fifth Hampden contract, so that the total number on order became 770. The last Hampden was completed in March 1942.

Development of Samlesbury aerodrome continued with the start of work on runway extensions in October 1940, and the completion of the large No.2 hangar at the end of that year. By February both the hangars approved in August 1940, and intended for Hampden repair and modification work, were under construction. Both were completed in the second half of 1941, as were the runway extensions. The final and largest hangar on the site was built between February and December 1942. As work on this hangar finished, construction was started on a concrete runway, which was completed in May 1943.

The first Halifax was delivered to Samlesbury from Strand Road in June 1941, as major assemblies for marry-up. This aircraft made its first flight on 15 August, 1941. Further contracts for Halifaxes were received during 1942 bringing the total on order to 1,520. Production of Halifaxes in 1942 averaged almost one aircraft a day.

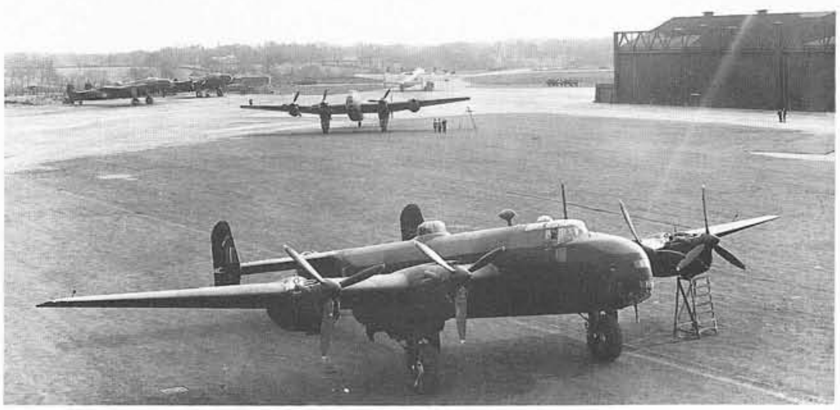
V

On 23 December, 1942, English Electric acquired the whole of the ordinary share capital of D. Napier & Son Ltd, a long established engineering firm with head offices and works in Acton, London. Originally founded in 1808, the company first began aircraft and aero-engine work during the 1914–1918 war. After the war the company's Lion aero-engine achieved considerable success, and at the outbreak of hostilities in 1939 the advanced Sabre engine was entering production. This engine was intended to be the powerplant of the Typhoon and Tempest fighters then under development. Before large orders for the Sabre were received, Napiers was a comparatively small company employing no more than several hundred people. For production of the Sabre a new factory was build by the MAP, to be managed by Napiers. This factory was situated in Liverpool, and was intended to have 10,000 employees. However, technical difficulties experienced with the Sabre engine and organizational problems due to the remoteness of the Liverpool factory from the Acton headquarters resulted in late deliveries. The immediate effect of these was delay in the introduction of the Typhoon and Tempest into service, a fact that was regarded with considerable concern by the MAP.

In November 1942, at the instigation of the MAP, George H. Nelson, chairman and managing director of English Electric, became an advisor to Napiers on the re-organizing of production. However, in December, with the approval and encouragement of the Ministry, an agreement was reached for the take-over of Napiers by English Electric. Thus it came about that English Electric entered the business of aero-engine manufacture, and at the same time joined the small group of aircraft companies building both airframes and engines.

VI

The most significant events at Preston during 1944 did not concern



A typical scene at Samlesbury in 1943. The aircraft are Mk II Halifaxes, fitted with front fuselages of the Series 1 Special and dorsal turrets of the Series 1A. In the foreground is JB928, which was delivered in April 1943, and served with No.78 Squadron. (*British Aerospace*)

production of the Halifax, which in 1943 had risen steadily towards the target of 60 aircraft a month. (The maximum monthly output was achieved in February 1944, when 80 aircraft were built.) Early in 1944 the MAP proposed that English Electric should undertake manufacture of the Folland Fo.117A fighter aircraft, which was intended as a successor to the Tempest then in service. The proposals also provided for the company to

Front and rear fuselages for Halifax B.IIIs awaiting transport from Strand Road to Samlesbury, October 1943. (*British Aerospace*)

Many official delegations visited Strand Road during the war. Typical was this party in October 1943, led by the Minister of Aircraft Production, Sir Stafford Cripps (in the centre, wearing the lighter suit). On Sir Stafford's right is Sir George H. Nelson, English Electric chairman; and Mr Arthur Sheffield, Preston works manager, stands on the other side of Sir Stafford. Note the woman worker in the Halifax centre fuselage behind the visitors. (*British Aerospace*)

undertake some of the design work, as well as production development. Accordingly, the design group, which had been established to work on modifications and repairs to Halifaxes, was increased in size. The Fo.117A, to specification F19/43, was a single-seat, cannon-armed fighter, powered by one Bristol Centaurus 12 engine driving contra-rotating propellers. However, after planning for design and production work had reached quite an advanced stage, the Fo.117A was abandoned owing to the forseeable introduction of jet-propelled aircraft.

A project briefly considered by the company during 1944 was the fitting of engines to Hamilcar transport gliders. An official requirement issued late in 1943 called for two engines to be installed in order to avoid anticipated difficulties when the Hamilcar was eventually used over long distances in the Pacific war. English Electric considered fitting two Bristol Mercury engines, which were to be obtained from Blenheims. However, initial investigation of the proposal showed that Hamilcars would not be able to land at Samlesbury as gliders with safety as the airfield was too small. Take-off for the powered glider, under its own power alone or towed, would also have been marginal. Since to have undertaken the work of fitting engines at Samlesbury would have involved dismantling the aircraft, English Electric decided not to proceed further with the proposal.

The de Havilland Vampire, one of the new jet fighters, had, by 1944, reached a sufficiently advanced stage of development for quantity production to be considered. The company chosen to build the Vampire was English Electric, on the basis of its performance in producing Hampdens and Halifaxes. Also, the abandonment of work on the Folland aircraft left resources intended for that programme available for other work. On 13 May, 1944, English Electric was officially notified that it was to receive Vampire production contracts. The first contract was placed

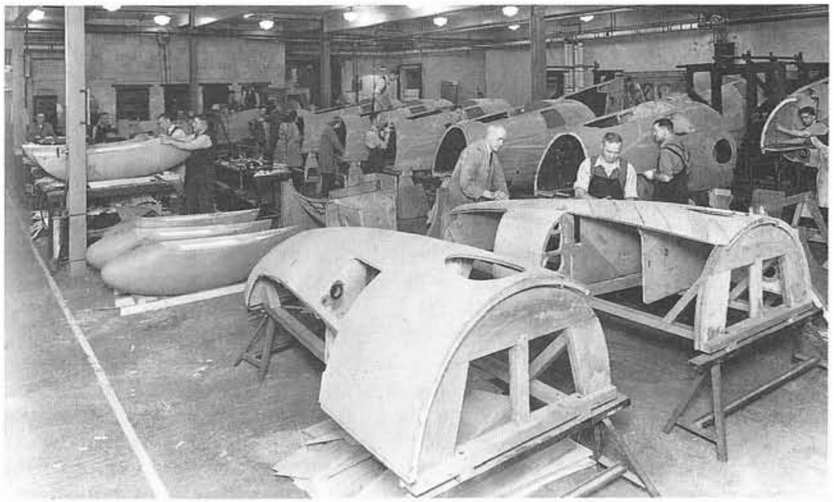
The TC premises in Corporation Street, Preston, in about 1945. In common with most wartime factories, there was no indication of the company actually occupying the premises. (*British Aerospace*)

during the following month, 120 aircraft being ordered.

In the early part of 1944 the directors of English Electric decided that the company should continue in aircraft work after the end of the war. This was a courageous decision, since conditions were certain to be difficult in the postwar aircraft industry. Military orders would be drastically reduced, so that firms within the 'family' of established aircraft companies were likely to experience a period of considerable shortage of work. For a newcomer, attempting to break into the 'family', life was likely to be especially difficult. The certainty that postwar orders to the industry would be greatly reduced meant that it would have been unrealistic to have expected sub-contract work. Thus, most if not all the aircraft to be built would have to be of English Electric design. Consequently, the first priorities after making the decision were the forming of a design team capable of conceiving and developing original designs, and the establishment of a development centre where prototypes could be built.

The premises chosen to house the design office and development centre were situated in Corporation Street, Preston. The building had been occupied before the war by Barton Motors. During the war, the premises were requisitioned by the government and used as a training centre for various types of tradesmen. After being taken over by English Electric in April 1944, the garage premises became generally known by the initials TC, derived from their previous use. The accommodation at TC consisted of showrooms and offices, which could be used as drawing and general offices, and also of a large workshop, suitable for development and limited production work. On 24 May, 1944, work started at TC on preparations for Vampire production, thereby avoiding interference with the Halifax work at the Strand Road Factory.

In July 1944, William Edward Willoughby Petter joined English Electric as chief engineer of the aircraft division. He was to be responsible for the



Assembly of the wooden sandwich panel structure for de Havilland Vampire cockpits at TC in July 1945. Work on underwing fuel tanks can be seen on the left. (*British Aerospace*)

William Edward Willoughby Petter. (*British Aerospace*)

conception of new aircraft designs, and was also to organize a design office capable of developing them. When he joined the company, Petter was only 35 years of age, but he had already had a notably successful career during 15 years with Westland Aircraft. After obtaining a first class degree in mechanical science, and a prize for aeronautics, at Cambridge University, he had gone to Westlands in 1929. In 1935 he became Westland's technical director, and as such was largely responsible for the design of the Lysander army co-operation aircraft. His next project was the Whirlwind day and night fighter of 1938, this being followed by the Welkin high-altitude fighter of 1942. During his last months with Westlands, Petter had been having preliminary thoughts on the subject of a jet-engined fighter-bomber. After moving to Preston, his first task was to organize the new design team at TC. Petter continued to consider the jet-powered fighter-bomber, but a new official requirement for a jet-engined high-altitude bomber soon turned his thoughts in that direction. With very limited facilities available, Petter and his new design team began general investigations of the problems associated with the concept of a jet-powered high-altitude bomber. The design of such an aircraft in 1944 involved working to the limits of knowledge in a number of fields.

On 6 April, 1945, a large press conference was held at the Strand Road factory. The primary object of this gathering was to show the visitors from the Press and other organizations the aircraft production work in progress at Preston. Hitherto this work had been covered by security regulations, but the approaching end of the war enabled restrictions to be relaxed. In an after luncheon speech, Sir George H. Nelson, gave an account of the wartime aircraft production effort, and made the first public announcement of the company's intention to build aircraft after the end of the war.

VII

By early 1945 the end of the European war had become largely a matter of time, and production of some types of war material therefore started to decline. The aircraft industry in general first began to reduce output in the second half of 1944, although heavy bomber production was maintained at a high level until the spring of 1945. Halifax output at Preston started to fall in April, and declined steadily in the following months. However, by this time the first English Electric-built Vampire was nearing completion, and the initial flight was made in April. Expenditure of effort on the Vampire programme had been increasing rapidly in the early months of 1945, and was further stimulated in May when another contract was received. This was the third placed with the company, and brought the total number of Vampires on order to 300.

Following the end of the European war in May 1945, Halifax manufacture at Preston was quickly reduced to about 10 aircraft a month. After four months with output at this rate, production ceased entirely in November 1945, following the completion of 2,145 aircraft. Production of the Hampden and Halifax by all manufacturers totalled 7,762, of which the English Electric share was 37.5 per cent.

The factory at Strand Road and the aerodrome at Samlesbury were fortunate in not being damaged by enemy action during the war, and consequently no aircraft were lost before being flown. Considering the large number built, the fact that a perfect safety record was achieved during flight testing was particularly creditable. (There was only one significant accident, when a Halifax burst a tyre on landing and was seriously damaged after leaving the runway and colliding with a large concrete mixer). Wartime production had not sacrificed quality for quantity, the safety record during flight testing being an important indication of this fact.

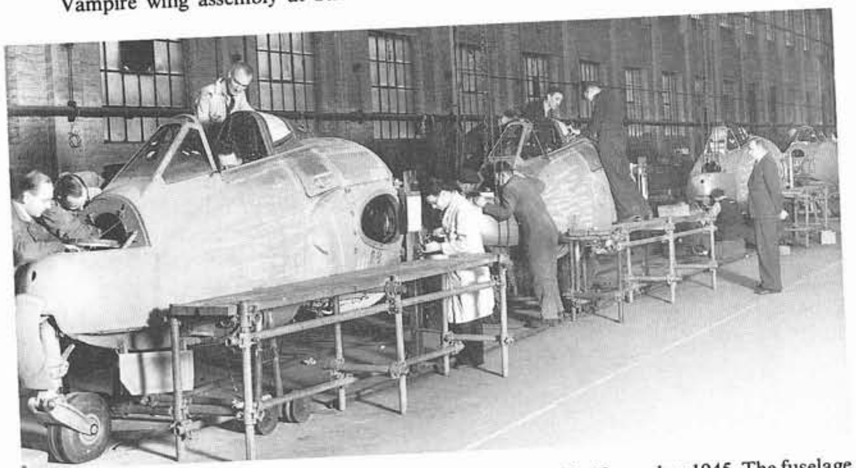
The production team at Preston during the war was led by Arthur Sheffield, general manager of the Strand Road factory. In the early years of the war H.G. Nelson, son of the company's chairman, became deputy general manager at Strand Road, and Richard Baines was aircraft superintendent. William Shorrock followed Nelson as assistant general manager, having previously played an important part in the initial organization of aircraft production. Shorrock's particular interests were labour recruitment and training, as well as wing and tail unit production. Robert N. Hollock was also closely concerned with the initial organization, being later responsible for the manufacture of detail parts and Halifax fuselages. In 1944, Hollock assumed responsibility for the Vampire programme. Final assembly work at Samlesbury was under the direction of George Walker, and John David Rose, the chief test pilot, was in charge of flight testing.

English Electric Aircraft Reborn

I

Following the end of hostilities the Air Ministry was reluctant to accept a rapid reduction of the aircraft industry, since it wished to re-equip the postwar RAF with the new aircraft then entering production. However, in

Vampire wing assembly at Strand Road, November 1945. *(British Aerospace)*



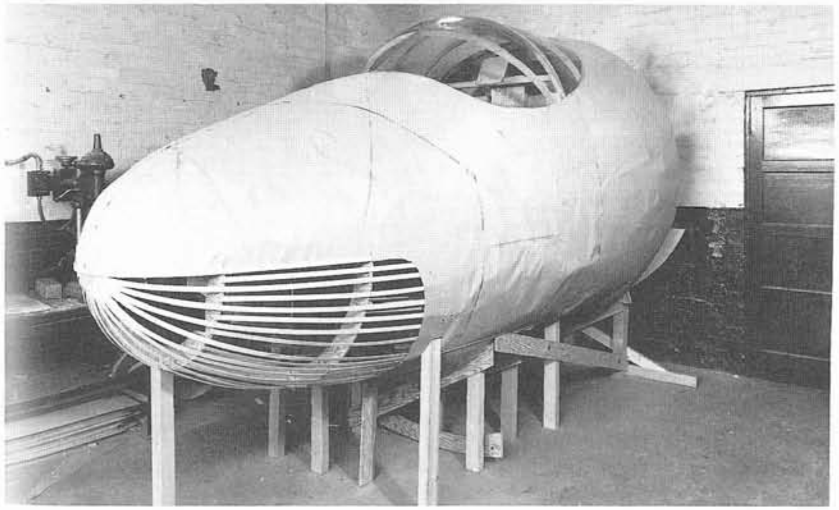
The Vampire F.I front fuselage assembly line at Strand Road in November 1945. The fuselage on the left was for TG306, which was converted to become the second D.H.108 research aircraft. *(British Aerospace)*

an eight-week period after the end of the Pacific war, the MAP cancelled a large number of contracts. The result was that the industry labour force was rapidly reduced by half a million, some 45 per cent of the total.

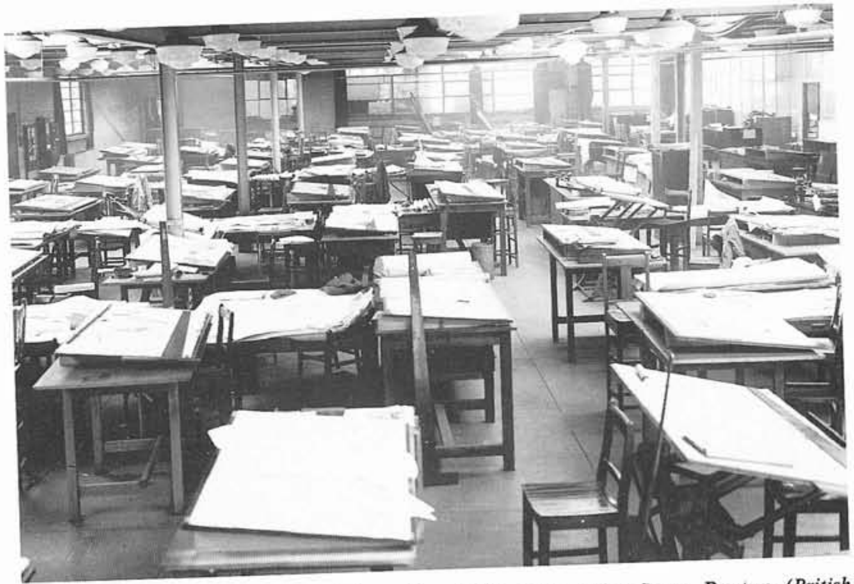
The cut-back of orders resulted in Halifax production at Preston being terminated, and Vampire orders being reduced, with lower output rates being specified for the aircraft remaining on order. Only six Vampires were completed before the end of hostilites, but the type was one of those chosen to re-equip the postwar RAF, and therefore remained in production. However, as the production effort necessary for the Vampire

Final assembly of Vampire F.Is at Samlesbury in October 1945. The 19th aircraft, TG292, is nearest the camera. *(British Aerospace)*

was far below that of the Preston works during the war, much of the factory capacity was available for non-aircraft work. Manufacture of diesel and electric locomotives, railway rolling stock and electric motors was recommenced, these items having been prewar products of the factory. For a time domestic appliances were also made. The Vampire work that remained at Preston served a valuable purpose, as continuity of aircraft production experience was maintained in the period when English Electric had no aircraft of its own design ready for manufacture.



The first English Electric Canberra front fuselage mock-up, seen at TC in September 1945, was built mostly of plywood and brown paper. The area of the radome for the radar bombing system has been left without a paper skin. *(British Aerospace)*



Birthplace of the Canberra—the design office at TC, Corporation Street, Preston. (*British Aerospace*)

II

Towards the middle of 1945 the design of the high-altitude jet bomber, which was eventually to become the Canberra, was beginning to crystallise. By late 1945 the design was sufficiently defined for a brochure to be submitted to the Ministry of Supply, and in January 1946 a contract was received for four prototypes. The bomber was at that time known as the English Electric A1, or sometimes as the B3/45, which was the number of the specification to which the prototypes were ordered.

During 1946 detail design work for the prototypes was started by the team at TC, which, towards the middle of the year, had grown in strength to about 100. Under the leadership of Petter were D.B. Smith, assistant chief engineer, and groups within the design team led by H.C. Harrison, the chief draughtsman, F.W. Page, the chief stressman, and D.L. Ellis, the chief arodynamicist. R.F. Creasey was a consultant to the last before joining the company in 1946 as a leading member of the design team. A few members of the team had started their careers in the workshops at Strand Road, but most were experienced design staff from outside the company. In addition to having a design team of considerable potential, the company had unsurpassed experience of modern techniques for the mass production of all-metal aircraft. Together these factors promised a great future for the A1 in particular, and for the company's aircraft work in general.

III

The aircraft manufacturing departments had a quiet year in 1946. After the hectic levels of wartime production, Vampire output of no more than

A group of leading members of the Canberra design team, in front of the first aircraft. Left to right: F. D. Crowe (structure design, chief draughtsman); D. L. Ellis (aerodynamics); H. C. Harrison (production design); A. E. Ellison (assistant chief designer); W. E. W. Petter (chief engineer); R. P. Beamont (chief test pilot); D. B. Smith (administration); F. W. Page (assistant chief designer); H. S. Howat (Ministry technical officer). (*British Aerospace*)

five a week was not remarkable. The upheavals which followed the ending of Halifax production resulted in most of the shops at Strand Road switching to non-aircraft work. From the fiftieth aircraft set, all Vampire components were built at Strand Road. This change was completed in March, and thereafter TC was able to concentrate on the A1 bomber. During 1946, 184 Vampires were completed, of which 52 were for export.

Vampire assembly used only a part of the floor space available at Samlesbury, and much of the remainder was occupied by Avro Lincoln bombers. English Electric obtained contracts to modify these aircraft, and this work started in January 1946. The programme involved extensive changes to the electronic systems of the aircraft. Five major systems were modified or fitted, and a large control console for two operators was installed in the fuselage. Three of the systems, Loran, Rebecca and Gee, were concerned with radio navigation, whilst a fourth was the H_2S radar. The fifth was the equipment for an automatic gun-laying turret. The existing rear gun turret was modified to be automatically aimed by this system, with the aid of a rearward-looking radar. Lincoln modification work continued for three years, being completed in December 1948. During this period over 200 aircraft passed through Samlesbury.

Vampire production during 1947 totalled 180, just over half being for export. The improved Mk 3 started to come off the assembly line in April and towards the end of the year output was typically 20 a month. The first of several large orders for Mk 5s was received late in the year. In 1948 the production rate was little different from that of the previous year, and just under 200 aircraft were built. Among the aircraft produced during the year

were the first of the Mk 5 fighter bombers, and further orders were received during the year.

IV

Continued expansion of the design team and design development work for the A1 during 1946 required facilities of a more sophisticated nature than those available at TC. In addition to these, an experimental flight-test aerodrome was also needed, as Samlesbury was not suitable for development for that purpose. The location chosen for the design centre and experimental aerodrome was at Warton, 7 miles to the west of the Strand Road factory. There a large aerodrome was already in existence, with extensive hangars and other associated buildings. Construction of the aerodrome had started in 1940, on flat land adjoining the mudflats of the Ribble estuary. Originally intended for use by the RAF, the aerodrome was allocated before completion to the United States Army Air Force. Work to adapt the site to USAAF requirements started in March 1942, and numerous hangars and extensive workshops, warehouses, barracks and other buildings were subsequently erected. In July 1943 the site came into use as one of four large Base Air Depots providing maintenance and other support facilities for the USAAF operational bases in Britain. The depot's activities expanded rapidly during 1943, eventually making Warton the second biggest American maintenance base in Britain, with up to 20,000 personnel employed there. A major function of the depot was the assembly of aircraft shipped in crates from the USA. The depot specialised in work on B-24 Liberator bombers and P-47 Thunderbolt and P-51 Mustang fighters. Major repairs, overhauls and modification work were

Roland Prosper Beamont. (*British Aerospace*)

done on many thousands of these aircraft, but numerous other types were also handled. After the end of the war USAAF activity declined very rapidly, and in November 1945 the base was transferred back to the RAF.

Postwar, the RAF used the buildings at Warton for storage, the aerodrome being virtually disused. When English Electric first became interested in the site, many of the buildings and facilities were in poor condition. However, the aerodrome had three asphalt runways, the longest of which was 6,000 ft, with space available for lengthening it if necessary. English Electric started to plan the development of Warton at the beginning of 1947. Only a small number of the numerous buildings on the site were initially used by the company, the first occupied being one of the larger hangars. The first research and development facilities, a low-speed wind-tunnel and a structural test frame, were to be installed in this hangar.

In May 1947, Roland Prosper Beamont joined English Electric as chief test pilot. After a distinguished wartime career, in which he reached the rank of Wing Commander, Beamont had become a professional test pilot. However, during his RAF service he had on two occasions been posted to Hawker Aircraft, and as a result had obtained 18 months' experience of flight-test work. After the war Beamont was employed by Gloster Aircraft and de Havilland Aircraft, and gained considerable experience of jet flying. At English Electric he joined the team designing the A1 jet bomber, although he also did a considerable amount of Vampire production test flying.

In mid-1947, English Electric received a contract from the Ministry of Supply to perform a series of test flights to investigate the behaviour of a high-speed aircraft during manoeuvres at high altitude. The aircraft used for the flights was a Gloster Meteor Mk IV, loaned to English Electric for the test programme. All the flying was done from Warton, with Beamont as pilot. The programme, started in August 1947, was the first flying done by English Electric at Warton, and was also Beamont's first experimental flying for the company. The conditions at Warton were distinctly primitive, and in great contrast to the sophisticated flight-test department that was to be established in later years. The flight-test team in 1947 consisted of Beamont and three ground staff. The foreman of the ground staff was William Eaves, who in later years was to accompany Beamont and the Canberra to numerous displays and demonstrations, in Britain and abroad. There were no air traffic control facilities at Warton during the Meteor flying, and the hangar in which the aircraft was kept was semi-derelict. The Meteor flight-test work was completed in July 1948.

The design team started to move from TC to Warton in May 1948. During the same month the first wind tunnel was completed at Warton, and later in the year further research and test facilities were installed. By the end of the year most of the design and technical staff had moved from Preston, although the total staff at Warton was under 200. The first wind tunnel was intended for low-speed experiments, and was of the closed-circuit type with a working section of 9 ft by 7 ft. A second wind tunnel, with a smaller working section and intended for testing models at speeds up to about Mach 0.9, was completed in July 1948. This tunnel was powered by a Rolls-Royce Nene turbojet, and was of open-circuit layout. Air was drawn through the working section by the turbojet, which was positioned downstream in the tunnel. This novel arrangement was

patented by English Electric. A water tunnel was added to these facilities in March 1949, and they were joined by special rigs for structural and mechanical testing. The most notable of these was a large structural test frame which was one of the largest of its type in the country. This frame was 75 ft long, 24 ft wide and 15 ft high. The wind tunnels and test rigs were designed and built almost entirely by English Electric at Preston, although other factories within the group made contributions.

V

Although the primary concern of the design office was the A1, an additional interest was the investigation of possible future projects and developments by a team led by R.F. Creasey. Towards the end of 1947 the Ministry of Supply began discussions with a number of aircraft companies, with the intention of making plans to enable the British aircraft industry to obtain experience of the techniques necessary for supersonic flight. English Electric was one of the companies involved in those talks, and in August 1948 a contract was received to undertake a design study for a transonic research aircraft. The study was completed late in 1948, and a brochure was submitted to the Ministry of Supply.

At the beginning of 1949 English Electric introduced a numbering system for its aircraft projects, new projects being designated P.1, P.2, etc, the 'P' meaning 'Project'. The first of the new designations was allotted in January 1949 to the transonic research aircraft, which was henceforth known as the P.1. (The new project numbering system was not retrospectively applied to the A1 bomber, but was used for later variants of that aircraft.) Four months after the P.1 brochure had been submitted, English Electric received official approval for work to start on the design of a prototype research aircraft. Thus was begun the development of the aircraft which was to become the Lightning supersonic fighter. The commencement of work on the P.1 resulted in the English Electric design team being concerned with both the first British jet bomber and the first British supersonic aircraft. That one design team should have responsibility for two such important projects was remarkable, especially since it had been formed only five years previously. Its success can be judged from the fact that in the first five years its members conceived two aircraft which were to provide nearly 20 years of production work for the company. Assembly of the first prototype A1 bomber was completed at Warton in the spring of 1949, and after brief ground tests, the aircraft made its initial flight on 13 May, 1949. This was the first new English Electric aircraft type to fly for 25 years. The early test flights of the A1 were very successful, and the few faults found in the aircraft were of a minor nature. The existence of the A1 was announced to the public after the first flight, and a further statement said that the type was to be named Canberra. The A1 made an impressive public début at the SBAC Farnborough Air Show in September 1949. Three further prototypes flew in the last seven weeks of the year, and by the end of December considerable progress in the flight-testing of the type had been made. In addition to the four aircraft flying, there were five more prototypes under construction, including those for the first production version, the B.2. By October the following year both the B.2 prototypes had flown, and the first production example was completed during that month.

VI

The outbreak of the Korean War in June 1950 resulted in expansion of the RAF re-equipment programme, with orders for several types of aircraft being increased. Further production orders for the Canberra were placed late in the year bringing the number of aircraft on order to nearly 350. However, the demand for Canberras to re-equip RAF Bomber Command became so urgent that English Electric alone could not cope, with the result that a sub-contract manufacturing programme was established. A.V. Roe, Handley Page, and Short Bros & Harland were selected by the Ministry of Supply to take part in this programme and each company was awarded a contract for one hundred Canberras late in 1950.

In order to cope with the large orders it had received, English Electric began expanding Canberra production facilities at Preston towards the end of 1950. Aircraft work was not, however, to occupy the whole of the Strand Road factory, which continued to build complete diesel and electric locomotives for some years. The company chose to increase its capacity by setting up another factory. This it did by taking over a Government-built factory situated at Clayton-le-Moors, near Accrington, an industrial town some 14 miles to the east of Preston, and only 7 miles from Samlesbury. Built in 1939 and 1940, the factory produced aero-engines during the war, up to 10,000 workers being employed. It was to be known as the English Electric Accrington works, and was well suited for Canberra manufacture.

With numerous versions of the Canberra being projected, English Electric also needed more design office capacity. An aircraft design team was, therefore, formed in 1950 at Acton, London, as part of D. Napier & Son Ltd, which had become a member of the English Electric Group in 1942. The team was to supplement the work of the main design centre at Warton, from which it received basic information and direction. The first major task of this team was to design the features of the Mk 8 Canberra peculiar to that aircraft. Napier also started to manufacture Rolls-Royce Avon engines under sub-contract in 1950, the company being one of a number undertaking this work. The Avon was in great demand, as it was the powerplant not only for the Canberra, but also for several other types which had been ordered in very large numbers.

The first definite indications of the success the Canberra was to achieve overseas came in 1950 with the agreement for the aircraft to be built under licence in Australia. This important event was closely followed by indications of an even greater achievement to come, when a party of United States officials visited Warton to inspect the aircraft. At first the suggestion that the Canberra should be built under licence in the United States was not taken very seriously. However, when the Americans asked that a Canberra should be demonstrated in the United States, English Electric began to realise that it had a good chance of achieving one of the most notable export successes by the British aircraft industry for many years.

In the course of about one year the Canberra brought the name of English Electric from relative obscurity to the forefront of British aviation. A new power had arisen in the industry, and although the foundations had been laid over at least ten years of hard work, the company's name seemed to many in the industry to have appeared almost overnight.

VII

While the Canberra was naturally the centre of attention in 1949 and 1950, the Vampire and P.1 were not being neglected. Vampire production continued steadily, about 24 aircraft a month being built in both years. However, the last order for the type was received in 1950, indicating that output would end around the time that Canberra production became established.

At the start of a new development cycle, the P.1 research aircraft was progressing through the various stages of design. An important milestone was reached in April 1950, when an order was received for two flying prototypes. However, some months previously the issue of specification F23/49 had caused thought to be given to the modification of the design to suit it for the role of fighter, and this work was increasingly to occupy the design team in the early 1950s.

W.E.W. Petter, who as chief engineer had been responsible for the conception of both the Canberra and the P.1, left English Electric in February 1950. He later joined Folland Aircraft and produced the Midge and Gnat lightweight fighter designs. At English Electric, Frederick William Page, who had previously been assistant chief designer, became chief engineer. He was to be made responsible for the design of the P.1 and its development into the Lightning fighter, and also for the later developments of the Canberra.

The design and development of the P.1 required a large amount of supersonic wind-tunnel work. English Electric decided to obtain its first supersonic tunnel by modifying the subsonic tunnel completed in 1948. By fitting modified liners in the working sections, speeds up to Mach 1.1 could be obtained, the first supersonic run being made on 20 July, 1950. This was the first privately-owned supersonic tunnel in Britain, and probably the first outside the USA. The pioneering work performed with this tunnel later received recognition when the first balance and P.1 model used in it were placed on permanent exhibition in the Science Museum, London. Although intended primarily for P.1 work, the tunnel also fitted into English Electric's overall plan to develop Warton as a comprehensively equipped research and development centre.

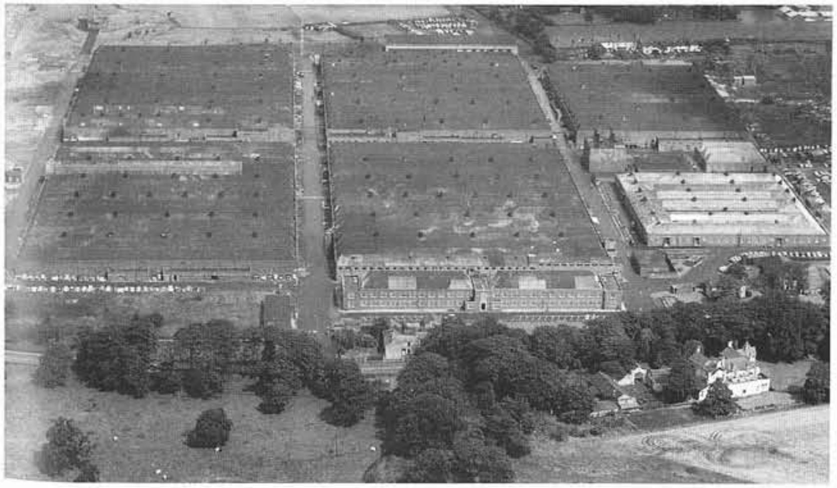
VIII

Canberra production increased slowly during 1951, reaching five aircraft a month by the year end. The prototypes of the PR.3 and B.5 versions made their first flights during the year, being the first developments of the basic B.2 to appear. Deliveries of B.2s started in the spring, most of the aircraft going to research and development establishments, although in May the first RAF Canberra squadron started to form. With the modernisation and expansion of Bomber Command continuing to have high priority, further orders for the Canberra were placed.

Although the British Canberra programme made significant progress during 1951, the most important event of the year concerned American production. On 18 April, 1951, an agreement was signed for the Canberra to be built in the USA by the Martin Company of Baltimore, Maryland. This agreement was a major triumph for the British aircraft industry, as well as for English Electric, as no British military aircraft had been built in the USA for over 40 years. The final factor influencing the choice of the Canberra as the USAF's next light bomber was a highly successful demonstration of the aircraft at Washington, D.C. During the flight from Britain to America, the aircraft made the fastest ever transatlantic flight, although an official record was not established. Six months later a second Canberra flew to America, and the opportunity was taken to set a new official time for the Atlantic crossing. As a result the flight made headlines in many countries, the Canberra thereby obtaining much free advertising! Numerous record-breaking flights were to be made by Canberras in the 1950s, and the publicity which these flights received no doubt played an important part in gaining export orders. While the agreement for production under licence in the USA was being finalised, preparations were starting to be made for the manufacture of Canberras in Australia. By the end of the year there were thus five companies in three countries preparing to build English Electric's Canberra, which was a drastic change of affairs from the time, only a few few years before, when English Electric had been sub-contractors to other companies.

IX

Vampire output steadily decreased in the later months of 1951, and was completed in February 1952. A total of 1,369 aircraft had been built in just under seven years. Although this period had overlapped Halifax and Canberra manufacture, it also included five years when the Vampire alone had been in production. Thus one of the most important benefits to English Electric of Vampire work was the continuity of experience it provided. If the Preston factory had not built Vampires, aircraft manufacture would have ceased when Halifax contracts were cancelled at



The English Electric Accrington factory. The spacious layout in open country of the purpose-built factory was in sharp contrast to the Strand Road factory, which was built in stages over many years on a restricted site. (*British Aerospace*)

the end of the war. To have restarted aircraft work after a lapse of five years would have presented many problems. English Electric was therefore particularly fortunate to have received Vampire contracts, especially as aircraft orders were scarce in the immediate postwar years.

The completion of Vampire production at Strand Road and Samlesbury made extra manufacturing capacity available for Canberra work. In addition, the factory at Accrington, first occupied by English Electric late in 1950, started to contribute to Canberra manufacture at the beginning of 1952. During the period when preparations for Canberra work were being made, the factory was engaged in refurbishing a large quantity of air defence radar equipment. The first Canberra parts to be made at Accrington were rear fuselages: subsequently all the flying control surfaces and readily detachable airframe parts were made there. The latter group included such items as the fin, tailplane, engine cowlings, wing integral fuel tanks, and undercarriage-bay doors.

As Accrington was taking some of the manufacturing burden from Strand Road, production flight-testing was transferred from Warton to Samlesbury. With this move Canberra production became fully established, no significant changes being made to the organization during the remainder of the aircraft's production life.

The expansion of research and development test flying at Warton had caused the usual air traffic control and safety facilities to be provided, and also for some radio navigational aids to be installed. Warton airfield was well sited, with better approaches than Samlesbury, and was regarded as the master aerodrome. Flying at Warton was under the direction of Roland Beamont, the chief test pilot, his assistant being Peter Hillwood. Production test flying at Samlesbury was the responsibility of J.W.C. Squier, the chief production test pilot, assisted by J.W. Still.

The Canberra project continued to make progress throughout 1952 and 1953, reaching its peak by the end of 1953. In the summer of 1952 the prototypes of the T.4 and B.5 versions made their first flights, and the PR.3 entered production. A year later both T.4 and PR.7 aircraft started to come off the assembly line, so that four different marks were being produced simultaneously. The first export order was received in January 1953, from Venezuela, which was to prove in later years to be one of the best overseas customers for the Canberra. The three British companies which had received sub-contracts to manufacture Canberras all produced their first aircraft between October 1952 and January 1953. The following May the first Australian-built aircraft was completed, and two months later the first built in the United States made its initial flight. Thus by August 1953 six companies in three countries were building the Canberra. During 1952 and 1953 the Canberra was constantly making headlines as the type gained no less than 12 records. These included a double Atlantic crossing, the world altitude record, and three records set during the London to New Zealand air race. The serious business of re-equipping RAF squadrons was not neglected, however, for during the two years over 20 squadrons received Canberras.

Following the end of the Korean War in 1953, the British re-armament programme was reviewed, with the result that contracts for several types of aircraft were reduced. Orders for the Canberra placed with all four of the British manufacturers were either cancelled or amended. The revision of

Canberra front fuselages at a late stage of assembly, Strand Road, 1955. All are for B.6 aircraft, except the second and seventh from the camera, which are for PR.7s, being distinguished by their different Perspex noses. (*British Aerospace*)

Canberra orders had little effect on production until 1955. However, pointers to the future were apparent in 1954, when English Electric received orders for two of the more specialised variants of the aircraft. These were the interdictor B(I)8 and the high-altitude photographic-reconnaissance PR.9. These marks were to sustain production in the later years of the 1950s, although as they were ordered in far smaller quantities than the earlier B.2, the scale of production was to be much reduced. The most immediate result of this reduction was that both Handley Page and A.V. Roe completed their Canberra work in 1955. Short Bros & Harland, however, was to continue Canberra manufacture.

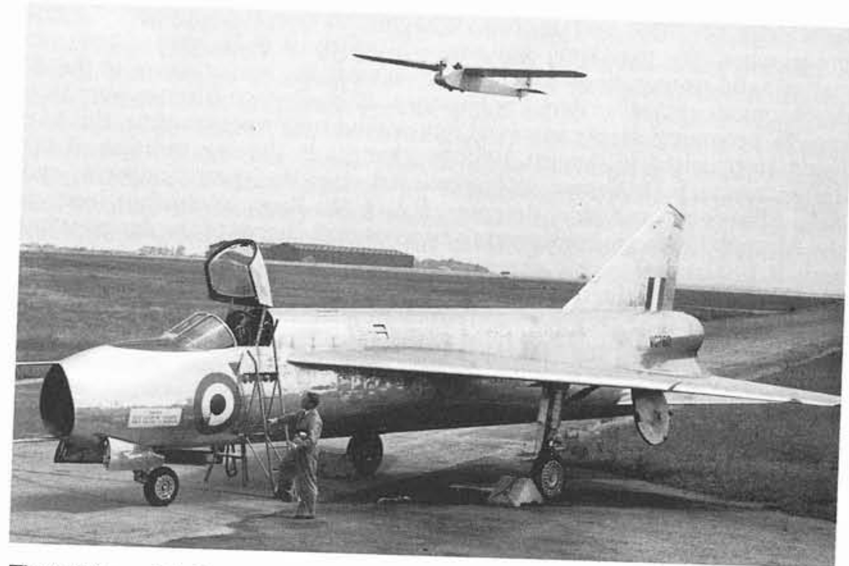
Production continued with the B(I)8 version, the first being completed in June 1955. The following month the prototype PR.9, destined to be the last new mark to be built, made its first flight. English Electric completed its five hundredth Canberra in August 1956, although by this time output had fallen to about three a month. If further export orders had not been received, Canberra production would have virtually finished by the end of 1957. However, in January 1957 a large order was received from India, being followed the next month by a smaller contract from Venezuela. Together these orders were for a total of 90 aircraft, which was a large enough quantity to enable production to be extended by about two years. When Canberra manufacture eventually ended late in 1959, production of the Lightning fighter was just starting, so that continuity of work was maintained. Thus the Indian order for Canberras was valuable not only for its size, but also for its timing. The Canberra was in continuous production at Preston, Accrington and Samlesbury for nine years. This relatively long production life provided the stable manufacturing and financial foundations necessary for the development of English Electric's Aircraft Division into a comprehensive and modern design and development organization.

Canberra final assembly at Samlesbury in 1959. The aircraft are for India and New Zealand. *(British Aerospace)*

Supersonic
I

While the success of the Canberra was receiving much publicity, work was progressing in secret on the P.1 project. The requirement for a supersonic fighter to meet specification F23/49 had resulted in a proposal to develop a fighter version of the P.1. The research aircraft was then designated the P.1A, with the proposed fighter being known as the P.1B. In August 1953, a contract was received for three P.1B prototypes and was followed six months later by an order for a batch of 20 development aircraft. There was thus every prospect that the P.1B would eventually enter large-scale production, ensuring continuity of manufacturing work after the completion of Canberra orders. By the end of 1953 assembly of the first P.1A was well advanced, with the initial flight scheduled for mid-1954.

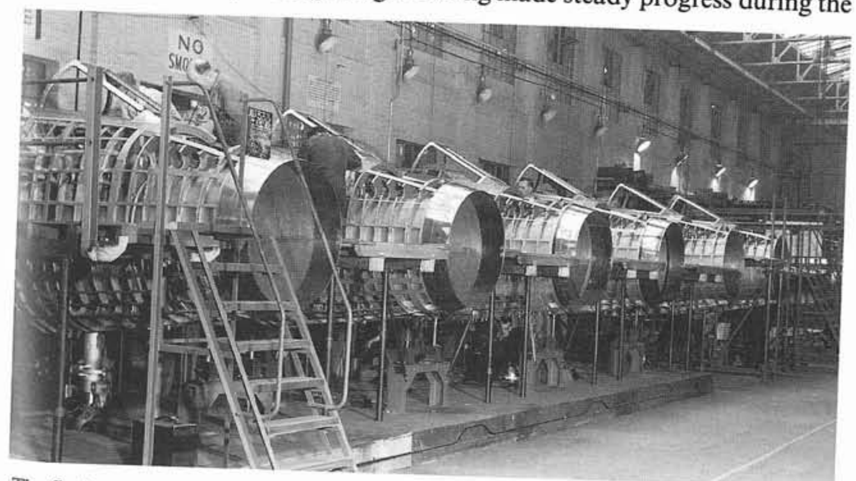
English Electric began to use computers to help solve design problems at a relatively early stage in the development of the P.1. The company did considerable pioneering work in the application of computers to aircraft design, and was one of the forerunners in this field. By early 1952 the ACE (Automatic Computing Engine) computer at the National Physical Laboratory was being used by the company, and in 1955 the Warton design team started to make use of the English Electric-built DEUCE (Digital Electronic Universal Computing Engine) computer at the company's Stafford works. A similar computer was also installed at Warton. The demand for supersonic wind-tunnel testing capacity generated by the P.1 programme caused English Electric to build another supersonic tunnel at Warton. Completed in 1954, this tunnel had a working section 18 inches square, and was powered by two Nene turbojets. By fitting different liners in the working section speeds between Mach 1.4 and Mach 1.7 could be obtained. Test results were recorded in digital form by automatic equipment, the DEUCE computer being used for subsequent interpretation and analysis. With the low-speed and transonic tunnels completed some years earlier, Warton had a versatile set of wind tunnels,



The tortoise and the hare at Warton, July 1957. The Wren, flown by Peter Hillwood, above the P.1A which Roland Beamont is about to fly. *(British Aerospace)*

although the quantity of tunnel testing required by the P.1 programme was so large that numerous tunnels at other establishments were also used.

By summer 1954 final preparations were being made at Boscombe Down for the P.1A's initial flight which was on 4 August, the pilot being Beamont. Only seven days later the first supersonic flight was made. As the first British aircraft capable of supersonic speed in level flight, the P.1A received extensive publicity. Flight-testing made steady progress during the



The final stages of Lightning front fuselage structure assembly. The aircraft are from the later part of the development batch with XG333 nearest the camera. *(British Aerospace)*

remainder of 1954, and in July 1955 the second P.1A joined the test programme. By that time building of the three P.1B prototypes had started, and preparations were being made for the manufacture of the 20 development aircraft ordered in February 1954. English Electric were thus rapidly becoming deeply involved in a second major programme, this fact being emphasised in August 1955 by changes in the organization of the design team. F.D. Crowe was appointed chief designer, Canberra, and A.E. Ellison became chief designer, P.1. F.W. Page, as chief engineer of the Aircraft Division, continued to be in overall charge of the design team, with R.F. Creasey as his deputy.

Manufacture of the batch of P.1 development aircraft started at Strand Road in 1956. The complete airframes were to be built at Strand Road, production standard jigs and tools being used. However, the intention was that a part of the work should be transferred to the Accrington factory when production became fully established. Final assembly was to be done at Samlesbury. The first production contract, for Mk 1 aircraft, was received by English Electric in November 1956. This contract ensured that the company would have a successor to the Canberra to follow it down the assembly line.

The two P.1As steadily accumulated flying time, the five hundredth flight being made in April 1957. In the same month the first P.1B prototype made its initial flight, and by February 1958 the second and third prototypes had flown. Three months later the first of the 20 development aircraft flew, and five more were completed by the end of the year. With more aircraft available, the pace of flight testing increased steadily. The first prototype continued to be used for high-speed testing, and in November 1958 it became the first British aircraft to fly at Mach 2. In October this aircraft had been named Lightning.

The early days of the Lightning assembly line at Samlesbury, January 1959. Development aircraft XG326, nearly ready for engine running, heads the right hand line. The nearest aircraft, XG327, is at the systems testing stage, with fuel, electrical and hydraulic rigs connected. (*British Aerospace*)

The flight-testing of the P.1B fighter was to be a large and complex task. Over 20 aircraft were to be used, each being employed in the proving of one aircraft system or aspect of performance. A high proportion of the test flying would be at supersonic speeds, which raised problems of navigation and air traffic control, not the least of which was the avoidance of causing supersonic booms over land. Various extra facilities and improvements were needed at Warton to satisfy the requirements of this test programme, and most of the necessary work was done during 1956 and 1957. This work included lengthening the runway, the building of a new control tower and the installation of an instrument landing system and long- and short-range radars.

The last major milestone in the development of Warton as a comprehensively equipped research and design centre was reached on 19 October, 1960. On this date two new supersonic wind tunnels were opened by the Minister of Aviation. Considered to be probably the most advanced in Europe, each of the tunnels was intended for a particular type of work. The larger tunnel, with a working section 4 ft square and airspeeds between Mach 0.4 and Mach 4, was to be used to test models of supersonic aircraft. The smaller tunnel could produce speeds between Mach 1.5 and Mach 6 in a working section 18 in square, and was intended for guided missile development work. Thus this tunnel was primarily for the use of English Electric's Guided Weapons Division with the larger tunnel being used by the Aircraft Division. A new wind tunnel, specially built for VTOL

Warton airfield, with the River Ribble and marshes in the background. The design and engineering buildings are in the foreground, the high-speed wind-tunnels are at top right, and the flight hangars are at top left. (*British Aerospace*)

(Vertical Take Off and Landing) research, came into use in 1963. The working section was 18 ft square, and special provision was made to investigate the complex ground effect interference problems experienced by VTOL aircraft. The tunnel proved to be highly efficient, although it was one of the cheapest of its type built anywhere. The new tunnels, with the three built earlier, provided English Electric Aviation with what was probably the most capable set of wind-tunnel facilities possessed by any company in the world at that time.

By 1960 Warton had a full range of test facilities in addition to the wind tunnels. Aircraft structures could be subjected to static, fatigue and pressure loads, and flutter behaviour could also be investigated. Rigs were available for testing mechanical, hydraulic, electrical, air and fuel systems and equipment under simulated operating conditions, including complete systems laid out as they would be in the aircraft. Comprehensive facilities for both ground and flight trials of radio, radar and armament systems were available. The flight-test department, in addition to having the use of a well-sited and well-equipped aerodrome, also had advanced data recording and processing equipment. In little over ten years English Electric had developed Warton into one of the best equipped aircraft research and development centres in Europe.

II

In the years when the main design team was concerned with the later developments of the Lightning, the advanced projects office was considering numerous ideas for future aircraft. The most important of these concerned a replacement for the Canberra, the eventual need for such an aircraft having become apparent in the mid-1950s. Preliminary work on this project started in October 1956, some months before the issue of an official requirement for a Canberra successor as GOR 339. During 1957 English Electric adapted its ideas to suit this requirement, the project being designated P.17. In September 1957, the Ministry of Supply invited submissions to GOR 339 from nine British aircraft manufacturers. English Electric was one of these, and in January 1958 the company submitted a brochure on its P.17 project.

During 1958 the Ministry of Supply made a technical assessment of the proposals it had received, and also considered other factors involved in the choice of the winner of the competition. The most important of these factors was the political policy of encouraging a reduction in the number of independent companies in the aircraft industry. Additionally, the development of an aircraft to GOR 339 was likely to be the largest task of its kind ever undertaken by the industry. The Ministry, therefore, let it be known that the contract for development of the GOR 339 aircraft would not be awarded to any one company. The bidders for the contract then started to consider joining with each other to form partnerships acceptable to the Ministry

English Electric eventually agreed to form a consortium with Vickers Ltd for the purpose of competing for the GOR 339 contract. The aviation interests of the Vickers Group were under the control of a subsidiary company, Vickers-Armstrongs (Aircraft) Ltd, with its main manufacturing and design facilities at Weybridge, Surrey. English Electric and Vickers-Armstrongs together submitted proposals to the Ministry, which on 1 January, 1959, announced that the two companies had won the GOR 339 competition. They were to share the work equally, although Vickers-Armstrongs was to be the prime contractor. The aircraft was to be known as the TSR.2. The first step taken by the two companies was the formation of a joint design team at Weybridge, in order to agree the configuration of the aircraft. Members of the Warton design staff were at Weybridge for most of 1959 as part of the joint team.

The eventual aim of the partnership between English Electric and Vickers was a complete merging of their aviation interests. However, English Electric's Aircraft Division was an integral part of the main company, and therefore required to be made a separate company in order to take part in a merger with Vickers-Armstrongs. On 9 January, 1959, English Electric announced the formation of English Electric Aviation Ltd, a subsidiary company which would take over activities concerned with aircraft and guided weapons. Work in each of these fields was to be the responsibility of separate divisions. The Aircraft Division, with its headquarters at Warton, was to undertake research, design and development work, but was not to have any production capacity. The factories at Strand Road, Preston, and at Accrington, were to remain under the control of the English Electric Company, as was the aerodrome at Samlesbury. The Guided Weapons Division, centred at Stevenage, Hertfordshire, and at Luton, Bedfordshire, took over the development and manufacture of guided weapons.

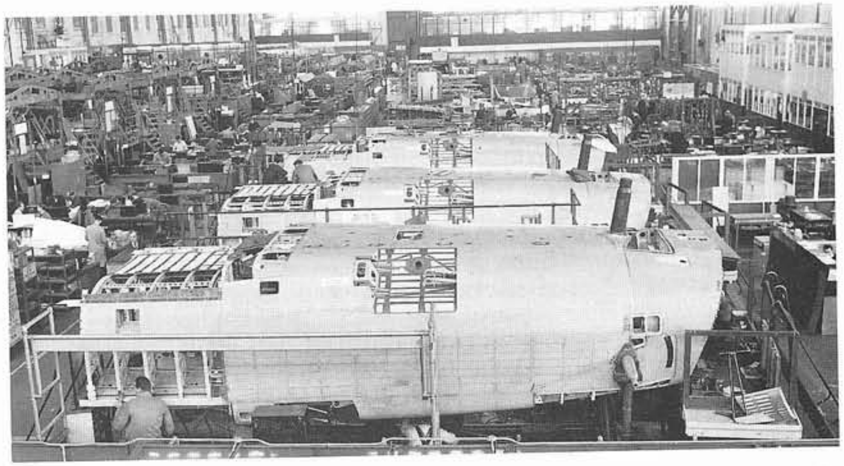
Amalgamation

I

During 1959 the Bristol Aeroplane Company became involved in the negotiations between English Electric and Vickers concerning their proposed merger. The Government's policy of encouraging the companies in the British aircraft industry to join together in larger units caused English Electric, Vickers and Bristol to consider forming their aviation interests into one group. On 12 January, 1960, the three companies announced their decision to amalgamate their aviation subsidiary companies, a new holding company being formed for the purpose. Named the British Aircraft Corporation Ltd, the holding company would have three operating subsidiaries, these being English Electric Aviation Ltd, Vickers-Armstrongs (Aircraft) Ltd, and Bristol Aircraft Ltd. Thus the names of the constituent companies were preserved. The shareholders in BAC were English Electric (40 per cent), Vickers (40 per cent) and Bristol Aeroplane (20 per cent).

Later in 1960 BAC obtained a controlling interest in Hunting Aircraft Ltd, of Luton, which became another operating subsidiary. The newly formed BAC had about 40,000 employees, and was thus comparable in size with the other major company in the British industry, the Hawker Siddeley Group, and also with United States aircraft companies.

After the joint English Electric and Vickers team at Weybridge had completed the TSR.2 configuration work in 1959, the personnel from Warton returned home to start the detail design of the parts of the aircraft



Rear fuselages for the third, fourth and fifth pre-production TSR.2s (XS662—XS664) in the last stage of assembly at Strand Road, early in 1965. (*British Aerospace*)

which were their responsibility. These were the wings, rear fuselage and tail. The front and centre fuselage sections were to be designed and built at Weybridge, where final assembly of the development aircraft was to be done. A contract for the full development of TSR.2 was received by BAC in October 1960, the construction of nine aircraft being covered by the contract. During 1961 and 1962 detail design made steady progress, and the manufacture of components started. In June 1963 a contract was placed with BAC for eleven pre-production aircraft, bringing the total number on order to twenty. By this time assembly of the first few aircraft was well advanced, and English Electric was thus rapidly becoming deeply involved in a second major programme, alongside that of the Lightning.

The first project to concern all the member companies of the British Aircraft Corporation was the Concorde supersonic airliner, which was designed and built jointly by BAC in Britain and Sud-Aviation in France. Most of the BAC part of the project was shared between Bristol Aircraft at Filton and Vickers-Armstrongs Aircraft at Weybridge, English Electric Aviation being responsible for a smaller part owing to its heavy TSR.2 and Lightning commitments. The design of the fin and rudder and a section of the rear fuselage was allocated to Warton. Although only a small portion of the total aircraft, these parts were in themselves, relatively large assemblies. Work started early in 1962 on the design of components for the two prototype aircraft. The original intention had been that the fins, rudders and rear fuselage sections for the prototypes should all be built at Strand Road, but following a re-assessment of work loads, the manufacture of the fin and rudder assemblies was transferred to Weybridge.

Although TSR.2, Lightning and Concorde work occupied most of the resources of English Electric Aviation in the early 1960s, the Canberra continued to provide valuable business for the company. In addition to small numbers of new and second-hand aircraft being sold abroad, numerous Canberras were returned to Samlesbury for overhaul or repair.

Late in 1963, the modification and refurbishing of B.2s to T.17s started, this being the first of several programmes of this kind for customers at home and abroad.

English Electric Aviation Ltd was re-organized in April 1963, as a move in the progressive integration of BAC subsidiaries. The company's Aircraft and Guided Weapons Divisions were dissolved. The guided weapons interests were merged with those of Bristol Aircraft Ltd, to form a new company, BAC (Guided Weapons) Ltd. The new English Electric Aviation Ltd was to consist of the aircraft research and development facilities at Warton, and also the aircraft manufacturing facilities at Preston and Samlesbury. The factory at Accrington, which was not wholly engaged in aircraft manufacture, remained part of the English Electric Company.

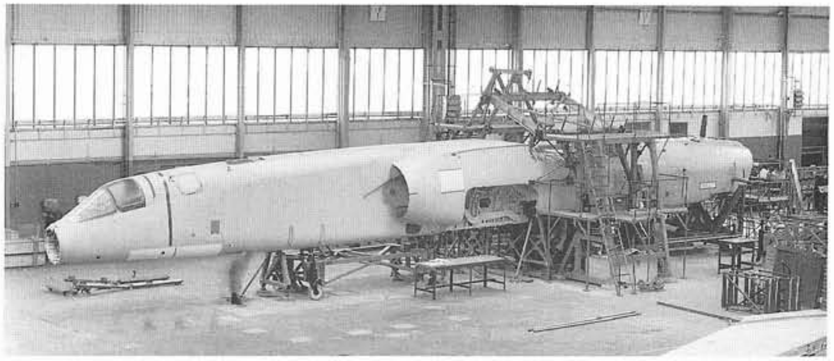
The final consolidation of BAC took place in January 1964. From the first of the month the Corporation's subsidiary companies became divisions of the Corporation. Thus the individual company names disappeared from the world of aircraft design and manufacture. English Electric Aviation Ltd became the Preston Division, the full legal title being BAC (Operating) Ltd, Preston Division.

II

Although the history of English Electric's aviation work strictly ends with the formation of BAC (Preston Division), it is of interest to consider briefly the later progress of the projects handed over to BAC. In addition, an outline of the way in which they were eventually replaced by a new generation of projects is also relevant, as the nature of these was largely decided by the company's previous experience.

BAC (Preston Division) was uniquely qualified to participate in international collaborative projects. As English Electric's Aircraft Division and later as English Electric Aviation, Preston Division had obtained broad experience of collaborative projects, both national and international. Thus by 1964 BAC (Preston Division) could draw on a fund of experience of collaboration which was unsurpassed in the British aircraft industry.

However, in 1964 the newly formed BAC (Preston Division) was mainly



The first pre-production TSR.2, XS660, in the fuselage marry-up jig at Samlesbury, early in 1965. (*British Aerospace*)

concerned with the TSR.2, fifty aircraft being on order. The initial flight was made in September, and the decision was made that Preston Division would become the main centre for the project, with all final assembly and flight testing of production aircraft being done at Samlesbury and Warton. Although by early 1965 the TSR.2 had demonstrated considerable technical success, the political prospects for the project were fading. In April the Government announced that the entire project was to be cancelled, this decision being the culmination of several years of adverse criticism from many sources. Although manpower in BAC (Preston Division) had to be reduced, the cuts were not severe, 1,200 employees being made redundant out of a total workforce of 10,200.

The impact of the cancellation was considerably lessened by Canberra and Lightning work being available for the manufacturing departments, and by the emergence of new projects in the design and development areas. Two sources of additional work were found, the first being the Jet Provost trainer, which was transferred to Warton from the Luton Division. The second new source of work was the sub-contract manufacture of rear fuselages for F-4 Phantom fighters being bought by Britain from the USA.

III

The first indications of a new project came early in 1965, when the British and French Governments began discussions with a view to the joint development and procurement of two types of military aircraft. These were a light-weight strike and trainer aircraft, and a heavier aircraft for the interdictor and reconnaissance roles. In May 1965, only one month after the cancellation of TSR.2, the two governments signed an agreement for the joint development and production of the two types. BAC (Preston Division) was the company nominated to be the British participant in both projects.

A unique family group at Warton on 16 July, 1965. The first TSR.2, XR219, is seen with F.6 (Interim) Lightning XR755 and Canberra B.2 WD937. This Canberra was the ninth production B.2, and is in the original black and grey paint scheme. (*British Aerospace*)

The smaller of the two Anglo-French aircraft was the Breguet Type 121 strike and trainer project, which was given the name Jaguar. Work progressed smoothly at Warton and in France, the first prototype flying in 1968. Production deliveries started early in 1972, some 400 aircraft being ordered by the British and French air forces, with additional aircraft being ordered by export customers.

The second Anglo-French aircraft was to have variable-geometry wings, and was known as the Anglo-French Variable Geometry (AFVG) aircraft. The French partner company was Dassault. (BAC's contribution was based on a series of design studies for variable-geometry aircraft begun in the early 1960s under the designation P.45.) Design definition work was undertaken by BAC and Dassault during 1966 and 1967, but in July 1967, before detailed work had started, the French withdrew from the project.

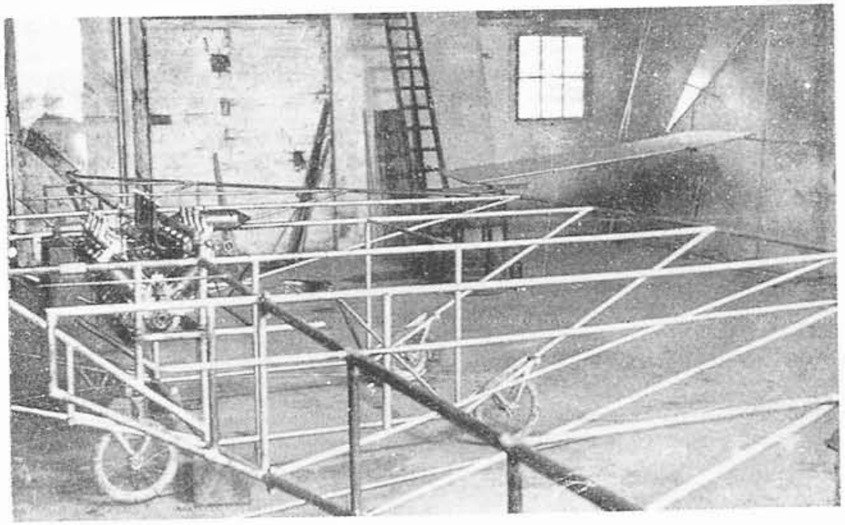
Following the collapse of the AFVG project, BAC (Preston Division) continued to study proposals for aircraft of the same type. These studies were supported by the British Government, which eventually became a partner in a six-nation consortium to design and build an aircraft to be known as the Multi-Role Combat Aircraft (MRCA). Although the consortium was soon reduced to three nations, Britain, West Germany and Italy, the project made good progress. Detail design started in 1970, and the first prototype, afterwards known as the Tornado, flew in 1974. Initial production orders from the three partner nations were for over 800 aircraft.

Thus by the early 1970s, BAC (Preston Division) was fully engaged in the development and production of two major projects, with substantial work continuing from earlier projects. The Division therefore had an assured future for many years. The change from the dark days immediately after the cancellation of TSR.2 was most marked, although nearly ten years had been required to recover fully from the effects of the cancellation. Further industrial reorganization came in 1977 with the formation of British Aerospace. This company brought together nearly all of the British aircraft industry, including BAC. The three sites at Warton, Preston and Samlesbury together constituted the largest Division of British Aerospace.

Epilogue

The companies which merged to form English Electric were involved in aircraft manufacture for a period of 11 years, and the company itself was directly engaged in this activity for a further 34 years. Thus the company and its predecessors accumulated a total of 45 years experience of aircraft manufacture. During this period extremes of fortune were experienced.

The attempt to continue in aircraft building after the 1914–18 war achieved very limited success, due mainly to lack of orders. The courageous decision to try again after the 1939–45 war was well rewarded, for English Electric quickly became one of the leading members of the British aircraft industry. English Electric's was the only significant new aircraft design team to be formed in Britain after the war, when numerous existing design teams were being merged or disbanded. The success continued in later years, and by the 1970s and 1980s the Warton-centred organization was the largest of its type in Europe, and arguably, the most capable and successful.



The first Howard Wright-built Capone helicopter under construction at Marylebone.

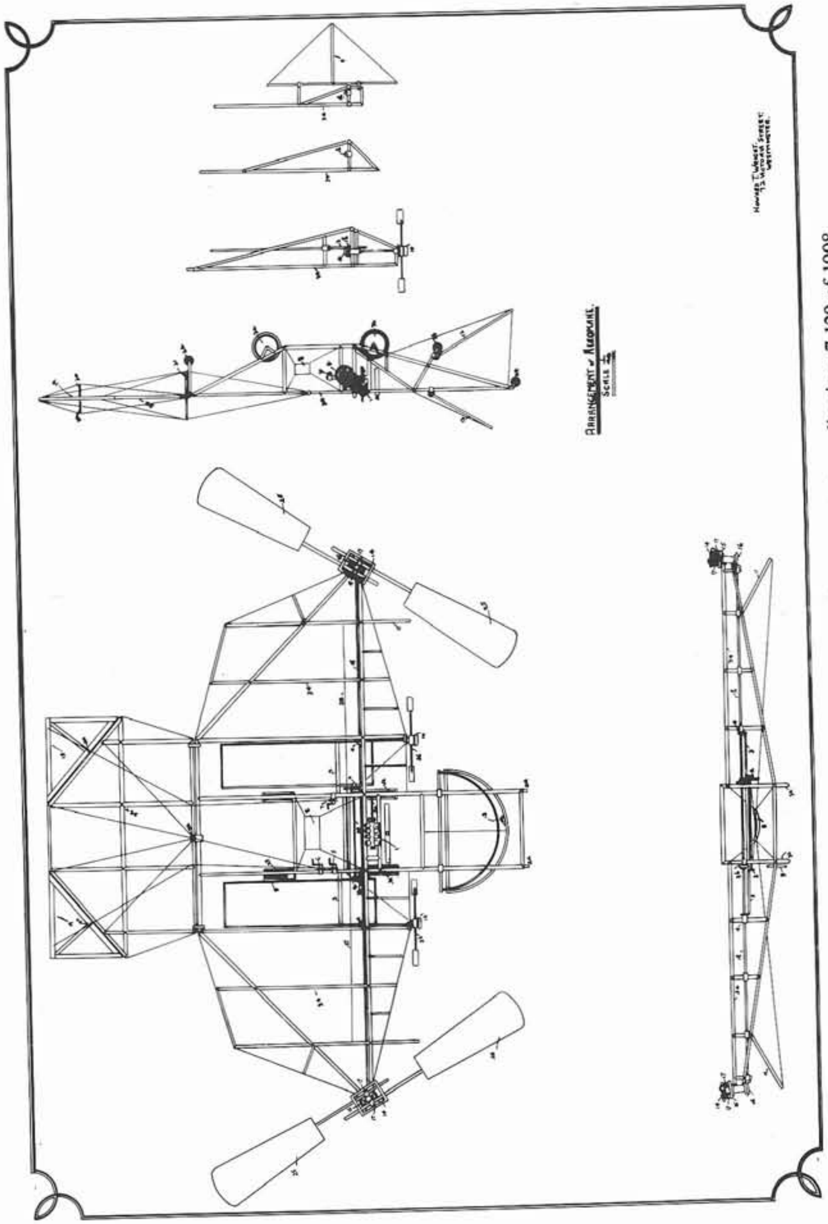
Howard Wright-Capone Helicopters

Among the first of Howard T. Wright's commissions was a helicopter, the product of the remarkably inventive mind of Federico Capone, whose work has remained relatively unknown because of his own modesty and horror of publicity. This helicopter was Capone's second design. His first was the result of some thirty years spent in research to solve the problem of flight, for which aim he had built in succession a series of models, several of them ingenious but quite complicated. In 1905, he achieved moderate success with his first full-scale experiment, when he, with the aid of his mechanic, Ceccarelli, constructed a form of pilotless helicopter. The main structure of the aircraft was built of steel tubing, as were the two rotors which were covered with aluminium sheet. The rotors were coupled and driven by a motor-cycle engine developing 4½ hp, and rotating cams were used to vary the incidence of the rotor blades to reproduce the helicoidal motion of rowing oars. The whole machine weighed only 240 lb. Capone proposed to launch the helicopter from a scaffold tower, erected in a field near the Coliseum in Rome, and to cushion its fall with a stretched cable. On 30 April, 1905, all was ready for the initial launch when a violent squall upset the aircraft, damaging the rotors. The trials were recommenced a little later and made at Altavilla Irpina, in the province of Naples, where the helicopter was launched from a high terrace and achieved sustained flight for a short distance. Having proved the rotor principle capable of practical application, Capone concluded that it would be necessary to pilot the aircraft to keep it in the air for any length of time and flying in the required direction. A modified form of this helicopter was granted British patent 28,590/1907.

In 1907, Capone moved to Arpaise in the province of Benevento and there designed a second helicopter based on his earlier experiments. Unlike the first its construction was undertaken by Howard Wright. Detailed drawings for the helicopter were completed at Howard's office at Belgravia Chambers during the winter of 1907–08 and shortly afterwards the aircraft took shape at the Marylebone workshops of Warwick Wright Ltd and subsequently at those at Battersea. The helicopter was built of thin-walled steel tubing, supplied by Accles & Pollock Ltd of Birmingham, welded together without the aid of sockets, to form a central box-shaped structure carrying two cantilever frameworks. The upper surface of the framework was extended in area by the addition of a steel tube lattice with balloon-cord leading and trailing edges, and the whole covered with fabric to provide flight surfaces. The rotors, their axes inclined outwards from the vertical, were mounted at the cantilevers' extremities and driven through a system of shafts and spur and bevel gears by a single 50 hp Antoinette water-cooled engine, mounted transversely within the central structure. Two paddle-shaped blades were fitted to each rotor, the pitch of which was varied by means of a cam such that the blades had incidence only when travelling rearwards. The main undercarriage comprised four rubber-tyred wheels, whilst six smaller wheels were used to prevent the helicopter toppling over on landing. The rear starboard main undercarriage wheel was driven by a chain from the rotor drive shaft to enable the helicopter to be taxied. Directional control and stability of the machine were achieved with a system of movable surfaces: a large tailplane hinged at the trailing edge of the main surface; two triangular rudders, built on wooden frames, hinged at the corners of the tailplane and two triangular surfaces beneath the rotors, which provided roll control and propped the aircraft on the ground. The control surfaces were cable-operated from three small winches placed within easy reach of the pilot who sat cradled within the central structure aft of the engine. Another somewhat curious control device was fitted: it consisted of two large rectangular surfaces, mounted adjacent to the main framework, driven by the engine through a gear train, an eccentric and a slide. The resultant flapping motion, according to Capone, created 'billowy-like air currents beneath the body of the apparatus to increase its stability.'

The flight of the helicopter, as envisaged by Capone, would have provided an interesting, if not alarming, spectacle. The rotors were to lift the aircraft to a reasonable height at which altitude the speed of the rotors would be reduced, and, because the machine's centre of gravity was well ahead of its centre of lift, the aircraft would glide forward. The extent of the flight surfaces was such that at 20 mph the helicopter was expected to support its own weight. After a certain interval and before the machine had reached the ground, the rotor speed would be increased to lift it once more into the air. By intermittently increasing and decreasing the speed, the aircraft would proceed in a series of curves or billows.

In March 1908, the completed helicopter was conveyed to the privacy of a large tent, erected at one corner of Norbury Golf Links, which were situated southwest of London on the road to Croydon. On Friday, 7 March, Howard Wright and his assistants wheeled the machine from its hangar and proceeded to test it in secrecy. The initial trials, which involved taxi-ing and tethered hovering manoeuvres, revealed a number of defects.



Howard Wright's drawing for Capone's helicopter patent application, 7,129 of 1908.

Contemporary reports of these tests and the accompanying descriptions of the helicopter fail to mention two small-diameter, four-blade tractor propellers geared to the rotor drive-shaft. The propellers are clearly visible in photographs (unsuitable for publication), of the helicopter at Norbury, and were shown on the drawing accompanying British patent 7,129 granted to Capone in 1908. Possibly, propellers were added in the intervening days before the helicopter's second series of tests in an attempt to provide forward movement. However, all of the tests proved unsuccessful, inasmuch as the machine failed to lift its pilot and only when its all-up weight of 1,250 lb had been reduced to 650 lb did it rise readily to two feet clear of the ground, a restriction imposed on the helicopter by its tethers. Clearly, the power of the engine and the size of the rotors were inadequate, although the rotors were considered to be particularly efficient, giving a lift of 33 lb/hp at the rotor axis, with the blades set at a maximum incidence of 37 degrees and rotating at approximately 100 rpm.

To achieve success, Capone was faced with several solutions by which he could improve the helicopter's performance: the main ones of which were to reduce substantially the all-up weight; increase the motive power or to improve the efficiency of the rotors. Capone took the last course of action by designing rotors of larger diameter, but also decided to design a new machine. Again, Howard Wright was asked to undertake its construction. Meanwhile, the helicopter at Norbury was dismantled for delivery to Capone in Italy.

In the course of designing the third helicopter a considerable weight saving was achieved and the need to install a more powerful engine, if one had been available, was less acute. The redesigned helicopter, according to the short-lived magazine *The Airship*, was fitted with a single 30 hp REP, seven-cylinder air-cooled semi-radial engine, and the weight of the aircraft, including the pilot, was 600 lb. The magazine continued: 'The fans are each 26 ft in diameter and run at 90 to 100 rev/min. The soaring speed is only about fifteen miles per hour, and as the old fans lifted 650 lb there should be plenty of power with the fans of the new machine, which are 6 ft larger in diameter. The motor is cooled by a large fan, which acts as a propeller. It weighs 130 lb complete in running order, with magneto, carburettor, pipes, oil and all fittings. The framework of the aeroplane is entirely of steel tubes welded together without sockets. It weighs but 120 lb, which is decidedly light in view of the fact that the main plane is 30 ft wide, 22 ft deep. The reduction gear, which transmits 30 hp and gives a reduction of 10 to 1, weighs 12½ lb. The 30 hp clutch weighs but 15 lb. Perhaps, however, the fans are most remarkable in this respect. Each of them only weighing 40 lb, including the hub. The blades are 6 ft 6 in long and 3 ft wide. The main plane is mounted on three strong motor-cycle wheels, with spring forks on the two in front, which are 20 ft apart.' In all other respects the third helicopter was similar to the second.

The fact that *The Airship* was able to give a detailed specification in November 1908, when the article was published, indicates that the design or construction of the third helicopter was very advanced and must have been started soon after the trials of its predecessor. On 9 January, 1909, *Flight* recorded: 'Howard Wright helicopter now completed and sent to Italy, tests in England were eminently satisfactory.' Much later, on 30 October, 1909, with Howard Wright in attendance, the helicopter was

The second Howard Wright-built Capone helicopter at Naples in 1909. (*C. F. Andrews*)

tested on the military parade ground at Naples. Of the trials *La Stampa* reported them successful and a French source stated: 'The inventor not having risked sitting in the machine to pilot it, the launch was made simply on the inclined plane which had been prepared to this end.'

Nothing further was heard of the helicopters but they were not to be Capone's last efforts in the field of moving wing aircraft, for it has been recorded that Howard Wright built for him an ornithopter and another helicopter. Details of the former remain unknown. Work on the fourth helicopter was started in June 1909 and was completed that year.

Helicopter No. 2

Span across tips of rotors 48 ft 2 in; overall length with rotors fore and aft 27 ft; rotor centres and wing span 28 ft 10 in; rotor diameter 19·ft 4 in; rotor blade length 6 ft 4 in; rotor blade maximum chord 2 ft 4 in; wing root chord 11 ft 8 in; tailplane span 13 ft 2 in; tailplane chord 8 ft 2 in; propeller diameter 4 ft 8 in; propeller centres 10 ft; undercarriage wheel base 6 ft; undercarriage wheel track 4 ft; wing area 160 sq ft; tailplane area including rudders 81 sq ft.
Weight loaded 1,250 lb.
Gliding speed 20 mph.

Helicopter No. 3

Span across tips of rotors 56 ft; rotor centres and wing span 30 ft; rotor diameter 26 ft; rotor blade length 6 ft 6 in; rotor blade maximum chord 3 ft; undercarriage wheel track 20 ft.
Weight 600 lb.
Gliding speed 15 mph.

Moore-Brabazon Powered Glider

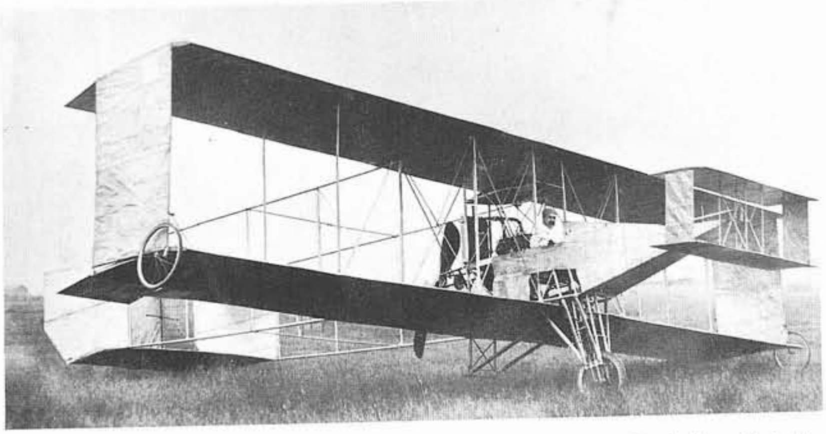
Inspired by the gliding of Archdeacon and Farman, J.T.C. Moore-Brabazon decided, on his return from France in the early autumn of 1907, to put his own ideas into practice. Armed with sketches for a glider with wings of about 25 ft span and a heavily cambered section, he asked the Short brothers, Oswald and Eustace, to undertake its construction. For £25 they produced a well-built aircraft of ash and bamboo with varnished balloon fabric covering the wings. They also took the opportunity to modify the original design, the result being that it appeared with a larger span and almost flat wings. The glider was controlled by a forward elevator mounted on triangulated outriggers, and drag-plate rudders attached to the outermost rear interplane struts. Landing skids and four jettisonable wheels comprised the undercarriage. On completion at the Short's Battersea works, the glider was taken to Brooklands and there housed in a shed alongside that of A.V. Roe's.

A few tests were made with the glider, but it was soon decided to fit a 24 hp eight-cylinder Buchet engine. In May 1908, Moore-Brabazon asked Howard Wright to make the required alterations for the engine. By the time Howard had completed his task at Brooklands, very little of the original glider was recognisable, although the 35 ft span wings were used without structural change. The modified aircraft retained the forward elevator, now carried on outriggers level with the lower wings, but was fitted with a fixed tail level with the upper wing. The engine drove a small-diameter pusher propeller with four paddle-shaped aluminium blades. The undercarriage, redesigned to have four castor-action wheels, was to prove the design's undoing for it was found to be weak and unsteady. The inadequate power of the engine also did not contribute to its success. Consequently, the biplane was not tested to any degree but remodified and flown as a kite by Moore-Brabazon at Chelmsford in Essex.

Howard Wright 1909 Biplane

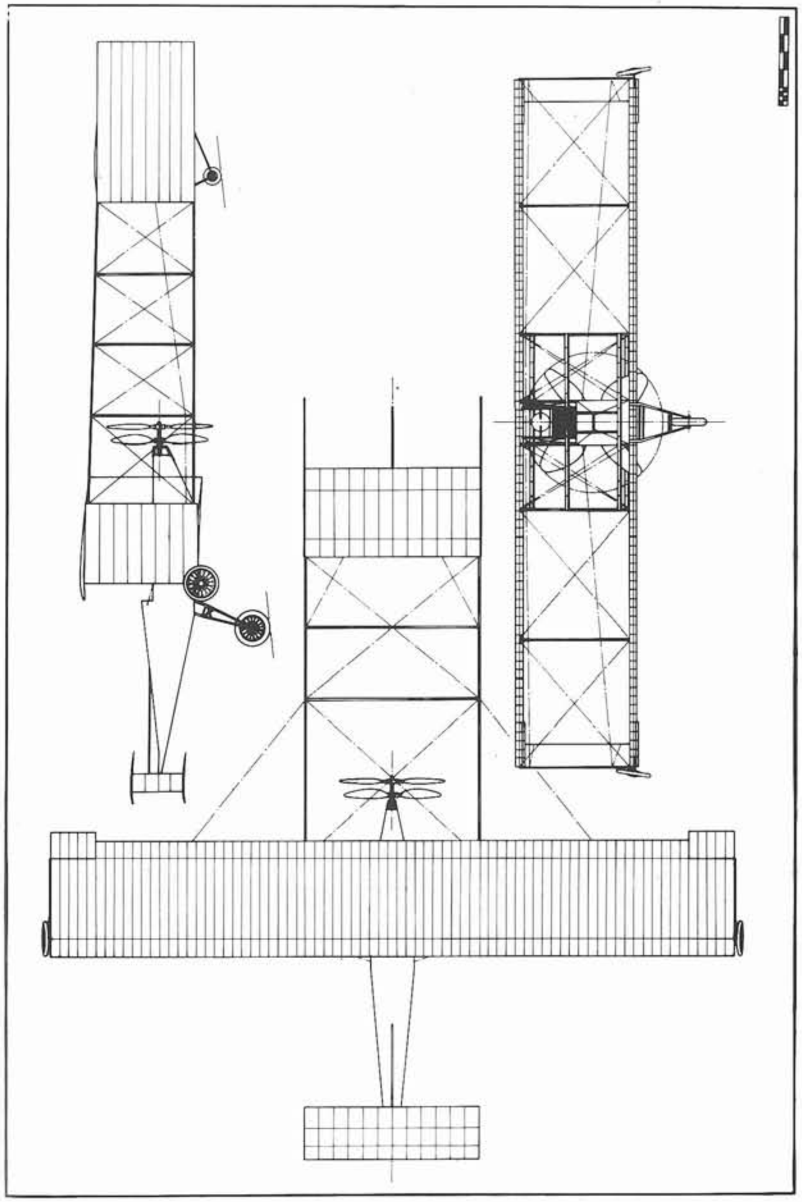
In December 1908, Malcolm H. Seton-Karr placed an order with Howard Wright for a biplane. Construction of the machine started immediately and it was completed in time for exhibition at the 1909 Olympia Aero Show, where it was acclaimed for its outstanding workmanship. The aircraft was noteworthy, also, for its strikingly clean appearance, indicating that contemporary aerodynamic theory had been applied with a degree of success, particularly by the introduction of a number of refinements to reduce drag. Clearly, this biplane was in advance of its time.

The biplane shown at Olympia followed Voisin lines but incorporated a streamlined nacelle for the comfort of the pilot. The nacelle was made of



Seton-Karr at the controls of his Howard Wright 1909 Biplane at Fambridge. Note the modified undercarriage, two-blade pusher propeller and the removal of the corners of the tailplane end-plates (*W. O. Manning*)

steel tubes welded together without sockets—a technique perfected in the course of constructing Capone's helicopters—and covered with silver doped fabric. At the aft end of the nacelle, a Belgian Metallurgique engine of 50 hp drove contra-rotating co-axial propellers through a patented 3:1 reduction gear, the forward propeller having blades of larger chord than the rear. A theoretical efficiency of 73 per cent was claimed for the propeller arrangement. The blades, which were made with constant incidence over their length, were of wood attached to steel shanks clamped offset to the propeller shaft. Petrol was gravity fed to the engine from a 15 Imp gal streamlined tank carried, like the radiator, between the interplane struts supporting the wing centre-section. The wings each had two ash spars reinforced with flitches of strip steel, and closely pitched ribs of spruce. The upper and lower surfaces of both wings were covered with fabric tautened with clear dope. No internal wing bracing was fitted, reliance being placed on spar stiffness. External bracing wires, streamlined interplane struts and fabric-covered end-plates maintained the wings in position. Construction of the forward elevator and fixed tailplane was similar to the wing, although the former dispensed altogether with bracing wires. The tail surfaces were carried on light tubular-steel booms braced with streamlined struts and wires. In addition to the forward elevator, operated by an irreversible screw from the cockpit, the biplane was controlled by four small wingtip ailerons connected through a closed-loop system of cables and struts joining corresponding pairs of ailerons, and a rudder mounted midway between the tailplane end-plates. The biplane was fitted with a monowheel undercarriage, based on the French REP monoplane, supplemented by wingtip wheels and a small tailwheel, this arrangement being considered to assist novice pilots to master the aircraft's controls before attempting flight. On the ground the biplane naturally rested on one of its wingtip wheels, in which state it remained until it had reached about 8 mph, when the machine would right itself onto an even keel. At 15 mph the tail was expected to lift, enabling the pilot to



Howard Wright 1909 Biplane.

manoeuvre the biplane in any direction on its mainwheel so that he could familiarise himself with the controls without leaving the ground. Only when the pilot felt himself in control was he expected to increase his speed to about 30 mph for take-off.

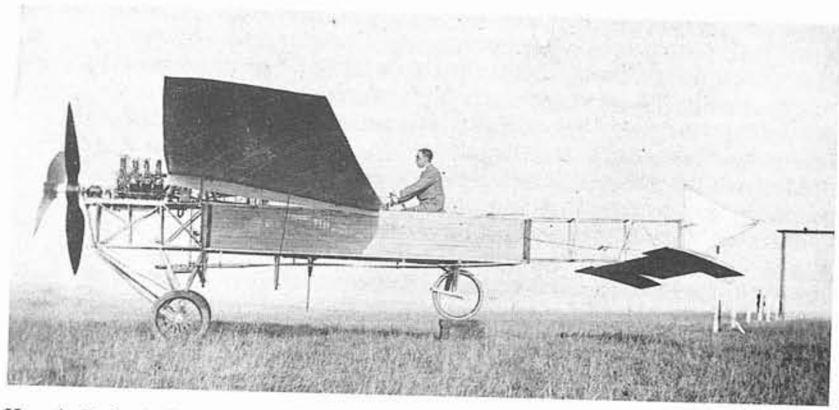
After the Show the biplane was taken to Fambridge aerodrome, Essex, where Howard Wright had erected a shed to house it. The journey was not without mishap, however, for the dismantled biplane was badly damaged on two occasions when the waggon carrying the wings was driven into a railway bridge by an inattentive carter, and, later, when the tail booms of the fuselage were broken in manhandling the machine across a ditch on to the flying ground. Then the shed was blown down in a gale.

By the begining of May 1909, the biplane had been repaired and all was ready for engine tests. No trouble was experienced in starting the engine but, on warming up, it inexplicably gained speed to such an extent that the propeller shaft sheared and fragments of blades were hurled in all directions, even through the iron roof of the shed, buckling and breaking the tail booms yet again. Repairs were put in hand immediately and the middle of June saw the biplane at last being tested under the direction of W.O. Manning. As might have been foreseen, Seton-Karr experienced considerable difficulty with the undercarriage for it necessitated taxi-ing the machine to a speed higher than estimated to put it on an even keel, whilst keeping it on a straight course. These problems were overcome with perseverance and by the end of the month short hops of about 30 ft were achieved. The rough nature of the ground at Fambridge was not conducive to further success and the biplane was taken for more trials, to Camber Sands near Rye in Sussex, where it was still flying in November 1909.

Sometime during the course of repairs at Fambridge the biplane was modified to incorporate two small bogey wheels just aft of the main wheel and it was possibly the use of these wheels which led to achieving short hops with the aircraft. Other modifications included additional bracing of the mainwheel, the removal, along a diagonal, of the bottom rear corners of the tailplane end-plates as they were liable to damage during taxi-ing and the replacement of the contra-rotating propellers by a single pusher propeller.

More than one source of information suggests that Howard Wright built another biplane along similar lines to carry a pilot and two passengers. It may have been an aircraft like this which W.E. Cooke contemplated buying in September 1909 before finally ordering a monoplane from Howard Wright.

Span 40 ft; length 43 ft; height 10 ft 6 in; wing chord 6 ft 6 in; gap 6 ft 6 in; propeller diameter 8 ft; total surface area 620 sq ft.
Weight empty 1,100 lb; weight loaded 1,600 lb.
Cruising speed 35 mph.
Price £1,200.



Horatio Barber's first aeroplane built for him by Wright and Manning at Battersea and seen here on Salisbury Plain. (*N. Parker*)

The Barber and Aeronautical Syndicate Monoplanes

Horatio Claude Barber returned to England from Paris, where he had been leading a somewhat leisurely life, early in 1908 fired with enthusiasm to design and build his own aeroplane, as a result of his visit to an exhibition of flying machines held at the Grand Palais. On his return, according to his own reminiscences, he found a suitable workshop in some disused railway arches at Battersea and there began construction, but, lacking engineering knowledge, entrusted the work to a consulting engineer. This engineer was Howard Wright.

The resultant two-seat monoplane was powered by a 50 hp Antoinette water-cooled engine driving contra-rotating propellers, the last feature possibly giving rise to or being derived from that incorporated in Seton-Karr's biplane which was under construction at about the same time. The monoplane's fuselage had a welded steel-tube structure, its only covering being provided by the Antoinette's radiators which occupied the full depth and almost the entire length of each of its sides. The wings were moderately cambered and were tapered over the majority of their span, the innermost portions being of parallel chord. They were hinged at the fuselage sides and interconnected by a system of bracing wires passing through the apexes of kingposts so that their dihedral would be self-adjusting according to flight conditions. This idea on automatic lateral stability was incorporated in patent No. 1999 filed by Barber in January 1909. Wing-warping control was apparently superimposed on dihedral movement, although it seems that the original intention was to fit full-chord wingtip ailerons. Longitudinal and directional controls were provided, respectively, by lever-operated elevators fitted to the ends of the tailplane, and a trianguar rudder. The pilot sat in line with the wing's trailing edge and the passenger was placed ahead of him. The

undercarriage consisted of two mainwheels attached to a transverse, leaf-sprung axle fitted to a system of V-struts, and a sprung tailwheel. It seems that wingtip wheels also were initially fitted but that these were discarded before or during the first tests. The monoplane was completed and delivered in the first week of June 1909 to Larkhill on Durrington Downs, where Barber had erected a shed to house it.

Meanwhile, the Aeronautical Syndicate Ltd had been formed in the preceding April. The directors and only shareholders at that time were Charles Worsley Battersby and Herman Rudolph Schmettau. The former was a stockbroker of the partnership of R.C. May and Battersby and the latter a solicitor of the firm of Hays, Schmettau and Dunn, who appear to have acted for Barber and provided him with a poste restante address at that time. Barber was the Syndicate's general manager but he never became a shareholder. At the formation of the company Barber sold it his patents, monoplane and hangar, by which it might be inferred that the Syndicate provided him with the finance necessary for him to continue his experiments.

During the course of the monoplane's trials several modifications were incorporated: the fuselage was completely covered; a triangular fin and rectangular rudder were added; a different form of elevator was fitted and a second tailplane was included above the fuselage immediately behind the pilot. The trials were unsuccessful, however, and the monoplane was subsequently dismantled.

The first of the Syndicate's own designs, known as the ASL Monoplane had the distinction of being the first full-scale aircraft of canard layout to fly in the British Isles. Designed by Barber and based on his experiments with model aircraft, it was built by Howard Wright and W.O. Manning at the Battersea workshops, during January and February 1910. On Sunday, March 6, with Bert Woodrow, the Syndicate's test pilot, at the controls the ASL Monoplane made its first flight, over Durrington Downs. Before the flight the pilot slowly taxied the machine for about ten minutes and with a following wind proceeded to take off. The aircraft left the ground in about 40–50 yards and rose steadily on an even keel to a height of 25–30 feet. After flying steadily for a short time, Woodrow switched off the engine, and in doing so let the monoplane land with a sideways swing, damaging a

Bert Woodrow at the controls of ASL Monoplane during trials on Durrington Downs in March 1910. (*via N. Parker*)

wing and the undercarriage. Repairs were put in hand and the aircraft later made further successful flights. This monoplane's fuselage, unlike that of its predecessor, was a wooden, wire-braced structure of rectangular section. A single 60 hp Green engine, driving a two-blade pusher propeller designed by Manning, was mounted aft of the pilot and passenger, the pilot being seated just forward of the wing leading edge and the passenger immediately behind him. The wings were tapered in plan and had a deep aerofoil section of heavy camber set at a small angle of incidence. The rear spar of the wing was pivoted to the fuselage to assist foot operated warping control. *Pegamoid* cloth covered both wing surfaces. The foreplane was fixed with a relatively large angle of incidence and was fitted with end-elevators which, like the small rudder mounted above the foreplane, were operated by hand levers placed on either side of the pilot. The main undercarriage was sprung on the Farman principle and was supplemented by a pair of nosewheels and wingtip wheels reminiscent of the 1909 Biplane.

At this juncture it seems a disagreement arose between Barber and Wright, which led to the Syndicate's severing connections with Wright's business. Subsequently, the Syndicate put into production the fairly successful Valkyrie monoplane, on which Barber gained his aviator's certificate No. 30 issued on 22 November, 1910.

Barber Monoplane

Span 32 ft; length 27 ft; wing area 200 sq ft.
Weight loaded 1,000. lb.

ASL Monoplane

Span 42 ft; length 31 ft; foreplane span 12 ft; wing root chord 10 ft; wingtip chord 6 ft; wing root thickness 8 in; wing dihedral 2° 18′; foreplane chord 3 ft; elevator span each 3 ft; propeller diameter 8 ft; propeller pitch 2 ft; wing area 310 sq ft; foreplane area including elevators 36 sq ft; total elevator area 18 sq ft.
Weight empty 802 lb.
Cruising speed 35 mph.

Howard Wright Glider

At the Battersea workshops, in June 1909, Howard Wright constructed a biplane glider which the technical press considered ideal for training purposes.

No detailed description of the glider or its subsequent history can be traced.

Cooke Monoplane

On 4 September, 1909, the *Burnley Express* reported: 'An enterprising Burnley gentleman has given an order to Mr Howard T. Wright for one of his well-known biplanes. The machine is of the latest type being

constructed of steel tubing, and having the most powerful engines [*sic*]. Strength has been the main consideration, and the machine, which is to carry three persons, will cost over £1,000. The biplane is already constructed, but Mr Wright will not allow it to leave the testing grounds until it has had at least a fortnight's thorough test. The Burnley gentleman has gone to London to receive instructions under Mr Wright, and he will probably take charge of the machine when it arrives in Burnley. Mr Wright imposes certain conditions in respect of the sale, and one is that the biplane shall not be purely for exhibition purposes, but shall fly.'

The enterprising gentleman was W.E. Cooke, who had varied business interests in Lancashire besides being managing director of the Burnley Motor Pleasure Co, and his biplane was to be used to establish the Burnley & District Aero Club, of which his eighteen year-old son, Granville, was to act as secretary. Local response to the aero club was good and naturally the subject of much discussion, Howard Wright having consented to become the club's first honorary member. Plans were made for the biplane to be flown at the first Blackpool aviation meeting and to be entered for the *Daily Mail* prize of £1,000 for the first circular flight of one mile by an all-British aeroplane. However, the club's immediate need was for a flying ground and though Howard Wright had twice visited Burnley to offer advice on this point, no suitable site was found in the vicinity. The club's promoters were forced to look elsewhere and after considering Freckleton Marsh, near Preston, finally rented land at Blackpool. The problem of the flying ground having been settled, another of finance arose, leading to various speculative reports that the biplane would not be bought after all. The doubts were quickly dispelled when it was announced that the East Lancashire Aeroplane Co, a syndicate headed by W.E. Cooke, had raised the purchase money by subscription, of which the largest amount had been contributed by Cooke. These difficulties had tended to delay the delivery of the aircraft but it finally arrived in Burnley on 9 October, 1909.

Shortly after placing his order, Cooke must have changed his mind as to the type of aircraft he proposed to buy, because the machine which was delivered was a monoplane. Cooke's intention to buy a monoplane was noted without explanation in the local press on 11 September. Undoubtedly, the change of order added to the delays, for a new aircraft had to be built. The monoplane was fitted with a single 50 hp Antoinette water-cooled engine driving a wooden two-blade propeller. The engine's long condenser radiators were attached along both sides of the fuselage. Petrol, sufficient for three hours' flight, was fed from the streamlined tank suspended from the cabane struts over the passenger, who sat well separated from the pilot within the fuselage which was built of light steel tubes. Warping control was applied to the tapered wings by means of foot pedals and the tailplane, fitted with end elevators, and a triangular rudder were operated from two small levers on either side of the pilot. The engine could be started by a small hand wheel placed on the pilot's left. The undercarriage followed Blériot practice.

The aircraft, untested, was transported by rail to Manchester and from there to Burnley, where it arrived at 9 am, four hours later than expected. It was taken directly to the Athletic Grounds at Brunshaw, Burnley, and quickly erected for its exhibition which was to be opened at 10 am by the mayor. However, after erection some difficulty was experienced in starting

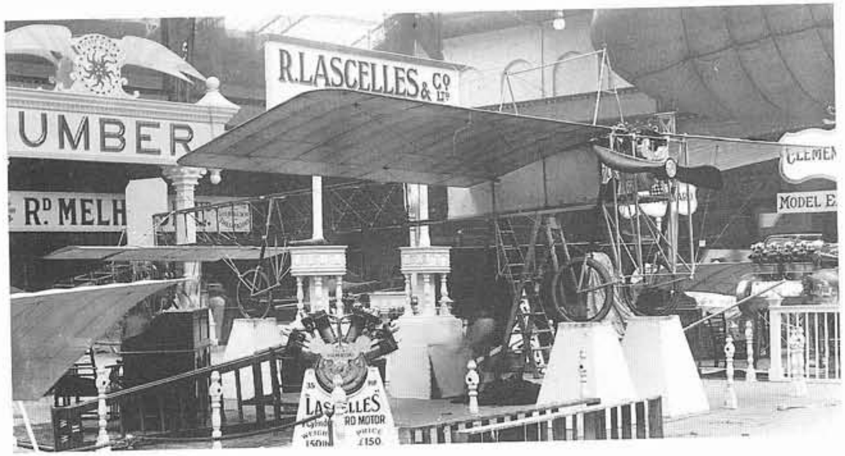
W. E. Cooke and daughter seated in the monoplane on the race track at Brunshaw, Burnley, before its first public demonstration. (*Leslie/Bruce Collection*)

the engine, it had become 'clogged up in transit.' These delays were sufficient to postpone the opening of the exhibition until the afternoon, during the course of which the monoplane was taxied round the running track with the mayor as passenger. The aircraft remained on exhibition until 12 October, after which date it was proposed to show it at Wigan, Southport and Manchester before taking the aircraft to Blackpool for its first flight. These plans came to nothing and the aeroplane was displayed only at Accrington and Blackburn. At the last of the exhibitions, held in a large hall at Blackburn, the propeller came adrift, whilst the engine was being warmed-up, and broke up on hitting the high roof of the building, causing considerable damage. After the accident the engine also was declared beyond repair.

The mishap at Blackburn was followed by the demise of the Burnley & District Aero Club and the disposal of the monoplane to the Northern Automobile Co, Bradford. This company advertised the aeroplane for sale at £200 and in doing so claimed that it was unused! The monoplane was subsequently bought by Harold Keates Hales, who had it transported to Hanley on the outskirts of Stafford. There Hales exhibited it at at least two park fêtes where he recovered in fees half the £150 he paid for the monoplane. On 10 July, 1910, Hales took the aircraft to Keele Racecourse for its and his first flight. In attempting to take-off, however, he pulled back on the elevator control lever too sharply: the aircraft leapt into the air, stalled and crashed to earth. Surprisingly, the monoplane was not totally wrecked and Hales escaped serious injury. The flight lasted 25 seconds.

A few months later the monoplane was again offered for sale, the advertisement in *The Aero* of 12 October stating: 'Magnificent passenger carrying Wright Monoplane, 50 hp Antoinette engine, not used, cost £1,000, bargain. H. Hales, Burslem.'

Span 32 ft; total surface area 240 sq ft.
Weight empty 750 lb; weight loaded 1,000 lb.
Estimated maximum speed 35 mph.
Price approximately £1,000.



The *Ornis* at the 1910 Olympia Aero Show.

Howard Wright 1909 Monoplane and Lascelles *Ornis*

At least three 1909 Monoplanes, designed by Howard Wright, were made at the Battersea workshops during the period November-December 1909. The aircraft were notable for being the subject of one of the earliest British attempts to introduce mass-production techniques into aircraft manufacture, by having a standard structure, so that delivery could be guaranteed within fourteen days. Of the three, two were known to have been powered by the 35 hp Lascelles four-cylinder semi-radial air-cooled engine, although any engine of suitable power could be fitted to the customer's requirements. Features introduced with the Cooke Monoplane were used in the design of the 1909 machine's undercarriage, tail unit, and also in the method of controlling the aircraft. However, the fuselage was made throughout of ash with steel angle-pieces and was wire-braced. The pilot, who sat level with the trailing-edges of the wings, which were of parallel-chord and had square tips, controlled the machine with two levers placed on either side of him. The right hand lever was used to warp the wings in conjunction with elevator movement and the left applied rudder. Contemporary records suggest that all the monoplanes were sold but do not state to whom.

A variant of the Monoplane was exhibited at the 1910 Olympia Aero Show. Known as the *Ornis*, it had been built for Richard Lascelles & Co Ltd, of 13 Greek Street, London, W.1, by Howard Wright in the month preceding the Show. The *Ornis*, with the exception of the rudder and method of control, was identical to the Lascelles-powered 1909 Monoplane, the rudder being rectangular in shape and the method of control, an

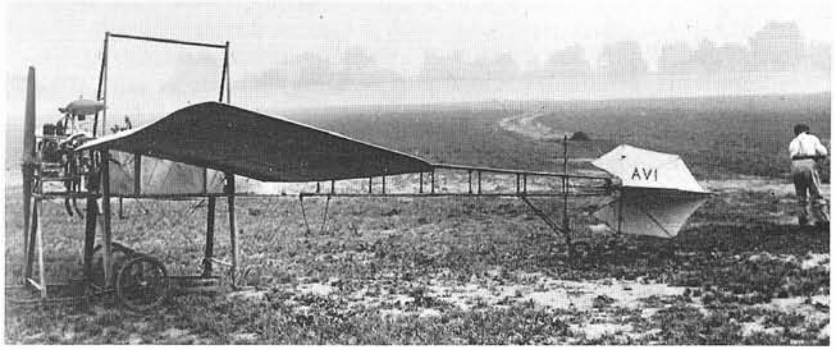
inclined steering wheel. The tractor propeller was made from Kauri pine by Weiss. After the Show, the aircraft was bought by A.G. Power, who experimented with it at Brooklands during 1910.

1909 Monoplane

Span 28 ft; basic fuselage length 27 ft; wing area 154 sq ft.
Weight without engine 350 lb; weight of 35 hp Lascelles 150 lb.

Ornis

Span: 28 ft; length 30 ft; wing chord 6 ft; wing dihedral 0° 38′; propeller diameter 8 ft; propeller pitch 3 ft; main undercarriage track 4 ft 6 in; wing area 154 sq ft; tailplane area including elevators 20 sq ft; total elevator area 10 sq ft; rudder area 5 sq ft.
Weight without engine 250 lb; weight loaded 600 lb.
Cruising speed 30 mph.
Price £450.



The Hon Alan Boyle's Anzani-powered *Avis* at Brooklands early in 1910. The authors believe that Boyle regarded this aircraft as his second machine because it had been re-engined with a slightly more powerful Anzani and the tail surfaces had been reduced in area. The photograph suggests that the machine was about to be named *Avis*, it having previously been known as the *Golden Plover*.

Scottish Aeroplane Syndicate *Avis*

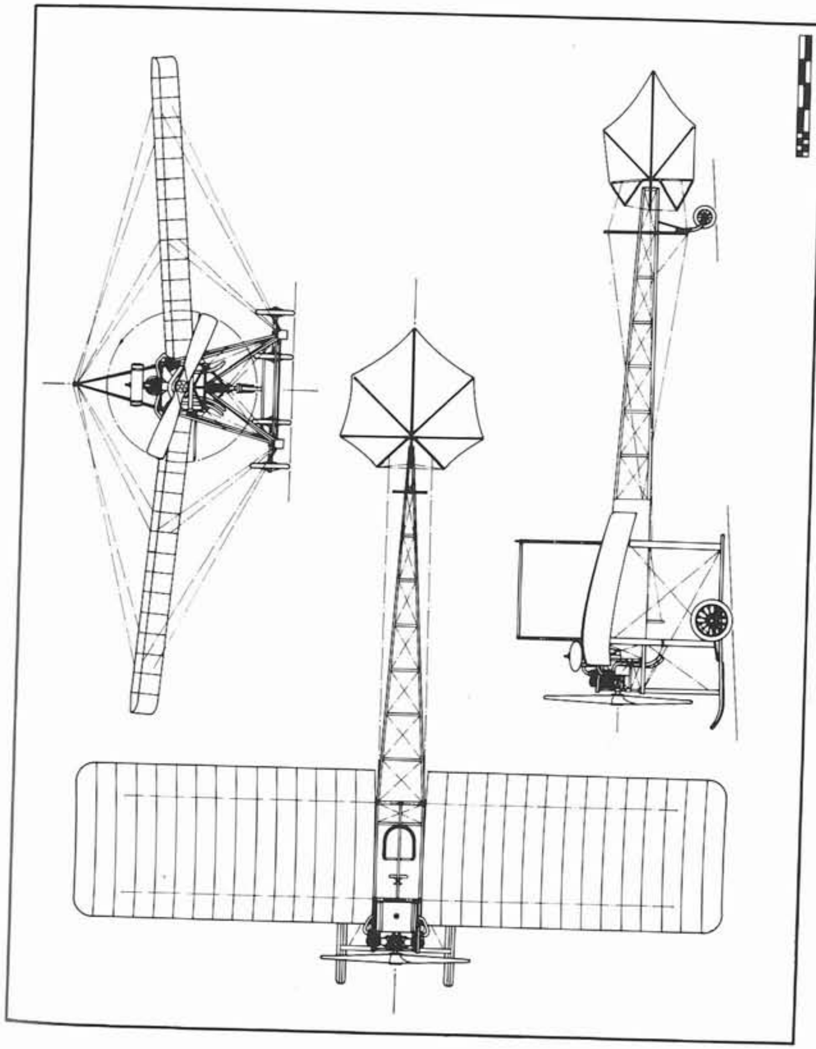
The *Avis* Monoplanes were designed by W.O. Manning and built by Howard T. Wright for the Scottish Aeroplane Syndicate of 166 Piccadilly, London, W. Known as the *Golden Plover*, the prototype, which was fitted with a 30 hp Anzani engine, was completed at Battersea in December 1909, and delivered to Brooklands for testing. In January 1910, the Hon Alan R. Boyle, who had founded the Syndicate made the initial trials. These did not prove entirely satisfactory and the aircraft was brought back to Battersea to be re-engined with a 35 hp Anzani. A tail unit of decreased area was also fitted. The aircraft, renamed *Avis*, returned to Brooklands,

J. Herbert Spottiswode flying *Avis III* at Brooklands.

where Boyle achieved his first straight flights with it in March and April, and his first circular flight in the following month. A little later, he flew the *Avis* at the 1910 Wolverhampton aviation meeting to win first prize for endurance in the monoplane class with a time in the air of 7 min 53 sec. Early in June, Boyle took delivery of a second aircraft of the type to which he allotted his personal coding, No. 3 being painted on the rudder. Apparently, Boyle regarded his previous machine as having two separate identities. The official nomenclature of Boyle's 'third' aircraft was *Avis I* and it was fitted with a 40 hp ENV engine. At Brooklands on 14 June, he used his new machine to gain Royal Aero Club Aviator's Certificate No. 13. Almost one month later, at the Bournemouth aviation meeting, Boyle was severely concussed when he crashed in *Avis I*. In the meantime the prototype *Avis* had been sold to Maconie.*

Meanwhile, the 40 hp JAP-engined *Avis II* had been exhibited at the 1910 Olympia Aero Show on the stand of the Aeroplane Supply Co, which acted as selling agents for the Syndicate. After the show it was bought by R.F. Wickham, who had the misfortune, whilst flying it, to experience an engine failure over the sewage farm at Brooklands. Wickham managed to land the aircraft but in doing so struck a raised cement canal crossing the farm. Damage to the machine was extensive. *Avis III*, also fitted with a 40 hp JAP engine, was purchased by J. Herbert Spottiswode, a well-known racing driver at Brooklands. On 5 October, 1910, Spottiswode piloted *Avis III* to fifth place in a competition sponsored by the Brooklands Automobile Racing Club, which offered monetary prizes for the greatest aggregate times in the air. N.C. Neill, offered a gold cup, also, to the pilot who flew the longest distance. The event was won outright by Graham Gilmour flying *Big Bat* with a total time of 2 hr 59 min 16 sec, Spottiswode's aggregate was less than five minutes. *Avis III* was later purchased by Campbell-Gray, a photographer of 88 Edgware Road, London, who used it for humorous publicity. On recovering from his accident, Boyle returned to flying at Brooklands with the purchase of *Avis IV*. With the collapse of the Syndicate, however, this aircraft became the

* Unfortunately nothing has been found to identify Mr Maconie or even confirmation of the spelling of his name. There was a statement in *The Aero* dated 10 August, 1910, which read 'Mr Maconie has put in several days practice on his Avis monoplane, and is rapidly gaining control of the machine.'



Scottish Aeroplane Syndicate *Avis*.

subject of the country's first recorded aeronautical auction, held in December 1910, when it was sold, complete with JAP engine, to Eustace Gray, Brooklands' press steward, for £50.

In appearance the *Avis* closely resembled many other single-seat monoplanes of the period but the type could be distinguished by its universally-mounted Demoiselle-style tail unit. The fuselage, made of ash, was of conventional wire-braced box-girder construction. The aircraft was controlled by warping the parallel-chord wings from foot pedals, and by the cruciform tail from a control column pivoted at its lower end, the elevator being operated by fore and aft movement of the column and the rudder by turning the wheel attached at the column's upper end. The twin-skid undercarriage was of sturdy construction and each item of it could be replaced without it being totally dismantled. Two pairs of wheels were attached across the skids by rubber cord shock-absorbers and the support for the small tailwheel incorporated a helical spring. The prototype aircraft was fitted with a Chauvière propeller but one made by Howard Wright from a single piece of Kauri pine was fitted together with the more powerful Anzani. All subsequent versions of the *Avis* had Wright-built propellers.

In flight the *Avis* was easily controlled and because it had been designed with its centre of gravity well forward, so that there was little or no load on the tail, the take-off was lively, the slipstream from the propeller immediately lifting the tail on starting the engine.

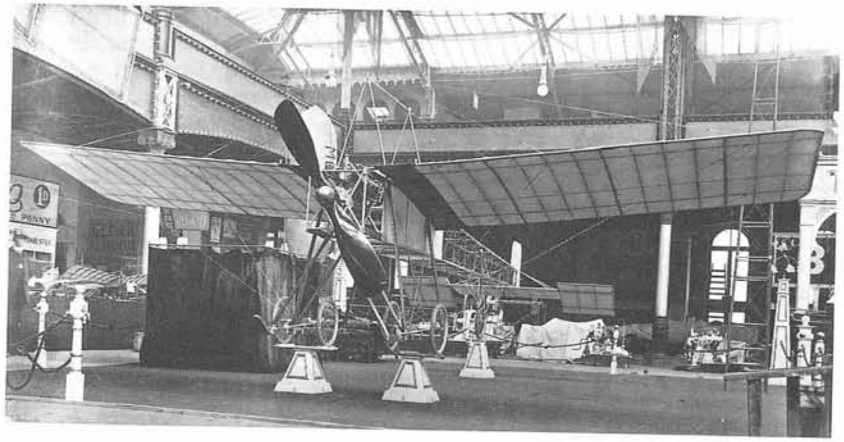
The design was developed further as the 1910 Monoplane.

Avis (as general arrangement)

Span 27 ft; length 27 ft; height 9 ft 2 in; wing chord 6 ft 4 in; wing dihedral 5°; wing incidence 9°; propeller diameter 6 ft 3 in; main undercarriage track 4 ft 6 in; wing area 170.4 sq ft; elevator area 22 sq ft; rudder area 14 sq ft.
Weight without engine 280 lb; weight empty 430 lb; weight loaded 630 lb.
Cruising speed 35 mph; maximum speed 40 mph.
Price £370–£490.

Howard Wright 1910 Monoplane

At the 1910 Olympia Aero Show, the stand of Warwick Wright Ltd displayed a new single-seat tractor monoplane, which combined features of the *Avis* and the earlier 1909 Monoplane. The aircraft also incorporated a number of refinements to reduce drag: the frontal area of the fuselage was kept to a minimum, being dictated solely by the envelope of the 40 hp ENV 'D' engine which had been installed; all fuselage and undercarriage struts were of streamlined section; flat steel ribbons were used for wing bracing; the radiators were mounted full chord at the wing-roots and followed the contour of the wing; and the propeller was given a conical spinner. Otherwise the monoplane was of conventional construction, having fuselage, wings and undercarriage similar to that of the *Avis* and a tailplane with end-elevators. A rectangular rudder was fitted, although



Warwick Wright's Monoplane at the 1910 Olympia Aero Show. (*Leslie/Bruce Collection*)

initial drawings of the monoplane show that it was to have had one of triangular shape. The monoplane, in fact, was the personal property of Warwick Wright and had been built for him by his brother, Howard, to the design of W.O. Manning, in the month preceding the Show. After the Show, Warwick took the aircraft to the Royal Aero Club's grounds at Eastchurch, where he made the first flight with it on Sunday, 3 April. Soon afterwards, the machine was taken to Brooklands and there Warwick made further flights of increasing duration. On his last flight, however, Warwick swerved to miss some wandering spectators and in doing so ran into a boulder which marked the limit of the sewage farm. The boulder took away the undercarriage but the fuselage and wings continued, depositing themselves and the pilot unhurt in the soft ground of the farm. Apart from the effects on his olfactory sense, Warwick was unshaken by the experience.

Shortly after the appearance of Warwick's machine at Brooklands, another version of the monoplane was flying there piloted by Capt G. Ll. Hinds Howell, an employee of Warwick Wright Ltd. Hinds Howell's aircraft was distinguishable from Warwick's by its full-span elevator and the block radiator mounted below its ENV engine. This monoplane made its first flight on 26 March, 1910. Further good flights were made with the modified monoplane but it met with an accident through a cause similar to Warwick's. On Saturday, 17 September, 1910, the aircraft's wing was damaged in a collision with the propeller of a stationary Weiss monoplane. Hinds Howell, whilst taxi-ing his machine, had swerved to avoid spectators.

In the following month, T.O.M. (later Sir Thomas) Sopwith and another variant of the monoplane made their début together at Brooklands. The aircraft arrived there from Battersea on 21 October, and Sopwith spent little time taxi-ing it before attempting a straight flight. After covering some 300 yards in a more or less steady state, he stalled the monoplane on landing and in doing so broke the undercarriage and propeller. The machine was soon repaired. His next attempts, made with more caution,

on Friday, 4 November, were rewarded with several straight flights and circuits. Five days later, flights ended with a burst cylinder-head, but on the following Monday, although the weather was bad, Sopwith went up again. Before the month was out, however, Sopwith had sold the monoplane in favour of an Howard Wright 1910 Biplane. In all major respects Sopwith's machine was similar to but slightly larger overall than Hinds Howell's, differing only in having a tailskid instead of a tailwheel and a single cabane strut in place of two wing kingposts.

1910 Monoplanes

Span 27 ft; length 29 ft; wing chord 6 ft 6 in; wing dihedral 2° 23′; wing incidence 9°; tailplane span 12 ft; tailplane chord 3 ft; elevator span each 3 ft; elevator chord 3 ft; rudder height 2 ft 6 in; rudder chord 3 ft; propeller diameter 6 ft; propeller pitch 2 ft 3 in; main undercarriage track 4 ft; wing area 160 sq ft; tailplane area including elevators 36 sq ft; total elevator area 18 sq ft; rudder area 7 sq ft.
Weight without engine 250 lb; weight empty 405 lb; weight loaded 605 lb.
Cruising speed 35 mph.
Price £630.

Howard Wright Demoiselle-pattern Monoplane

A single-seat single-engine tractor monoplane of Demoiselle-form was under construction in the Battersea workshops of Warwick Wright Ltd during January 1910. The fuselage, at that time, was almost complete and was a wire-braced structure of triangular-section with bamboo longerons and spacers of steel tube. Steel tubing, welded together, was used also to support the 30 hp Darracq two-cylinder water-cooled engine. The main undercarriage wheels were canted inwards, generally following the slope of the fuselage sides, and a small tailwheel was fitted. Construction progressed slowly, owing to work in hand on the *Avis* machines and Lascelles' *Ornis*, but by the beginning of the following February, the aircraft's heavily-cambered wings were complete and awaiting their fabric covering. The aircraft was completed in 1910, but no more is known about it.

Span 19 ft; length 21 ft; propeller diameter 6 ft 6 in; wing area 120 sq ft.
Weight loaded 255 lb.
Speed 48 mph.

Howard Wright Monoplane (Enlarged *Avis*)

A two-seat, enlarged version of the *Avis* was under construction by Howard Wright in March 1910. The aircraft was to be powered by a 60 hp Green engine, although an ENV engine could be fitted if preferred. This

machine was referred to in the technical press of that time as the Antoinette-pattern Monoplane.

Span 42 ft; length 40 ft; total wing area 320 sq ft.
Weight without engine 500 lb.

Howard Wright Blériot XII-pattern Monoplane

During the summer of 1910, Howard Wright completed a two-seat tractor aeroplane which had some of the features of the Blériot XII Monoplane. It was powered by a 60 hp ENV engine mounted low in the fuselage, the propeller being driven by a chain. The pilot and passenger, also positioned low in the fuselage immediately aft of the engine, sat with their heads just below or on a level with the wing. The tail unit comprised a monoplane tail with end-elevators and a small trapezoidal-shaped rudder. Although the fuselage was made of wood and acetylene-welded steel-tube, construction of the aircraft generally followed the practice of the period. The undercarriage was the usual arrangement of wheels and skids, with a sprung tailwheel.

Span 35 ft; length 46 ft; propeller diameter 8 ft; propeller pitch 3 ft 6 in; total wing area 360 sq ft.
Weight empty 1,100 lb.

E. J. Poynter and the Poynter Monoplane built by Howard Wright, seen at Brooklands. (*W. O. Manning*)

Poynter Monoplane

During May 1910, Howard Wright built a single-seat tractor monoplane designed by E.J. Poynter, a well-known artist who lived near Brooklands.

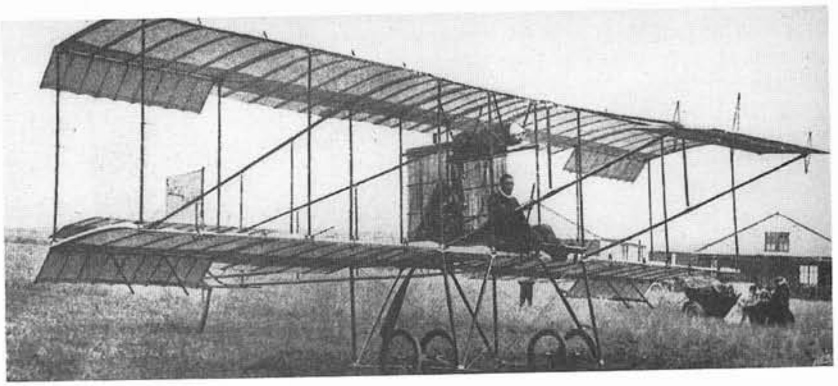
The monoplane was of sound design and bore the hall-marks of Wright's first class workmanship. It followed conventional construction of the period but was readily distinguishable by its large Demoiselle-style tail and tapered wings. Power was provided by a 60 hp Green engine driving a two-blade propeller. Construction was undertaken at Battersea and tests were made at Brooklands in June but the aircraft was never flown, because Poynter was injured in a car accident.

Span 45 ft; length 28 ft; wing root chord 9 ft; wingtip chord 6 ft; wing area 320 sq ft; elevator area 60 sq ft; rudder area 30 sq ft.

Howard Wright Curtiss-pattern Biplane

During the latter part of 1910, Howard Wright completed a single 35 hp-engined pusher biplane on the lines proposed by Glenn Curtiss, of the USA. No drawings or photographs of the aircraft have survived and it must be presumed that Howard's design incorporated the predominant features of a Curtiss biplane of the period, namely mid-gap ailerons and a tricycle undercarriage. In other respects the Curtiss machine resembled the Howard Wright 1910 Biplane.

Span 33 ft; wing area 270 sq ft.



'Jack Dare' with his Howard Wright 1910 Biplane, the second built, at Eastchurch in October 1910.

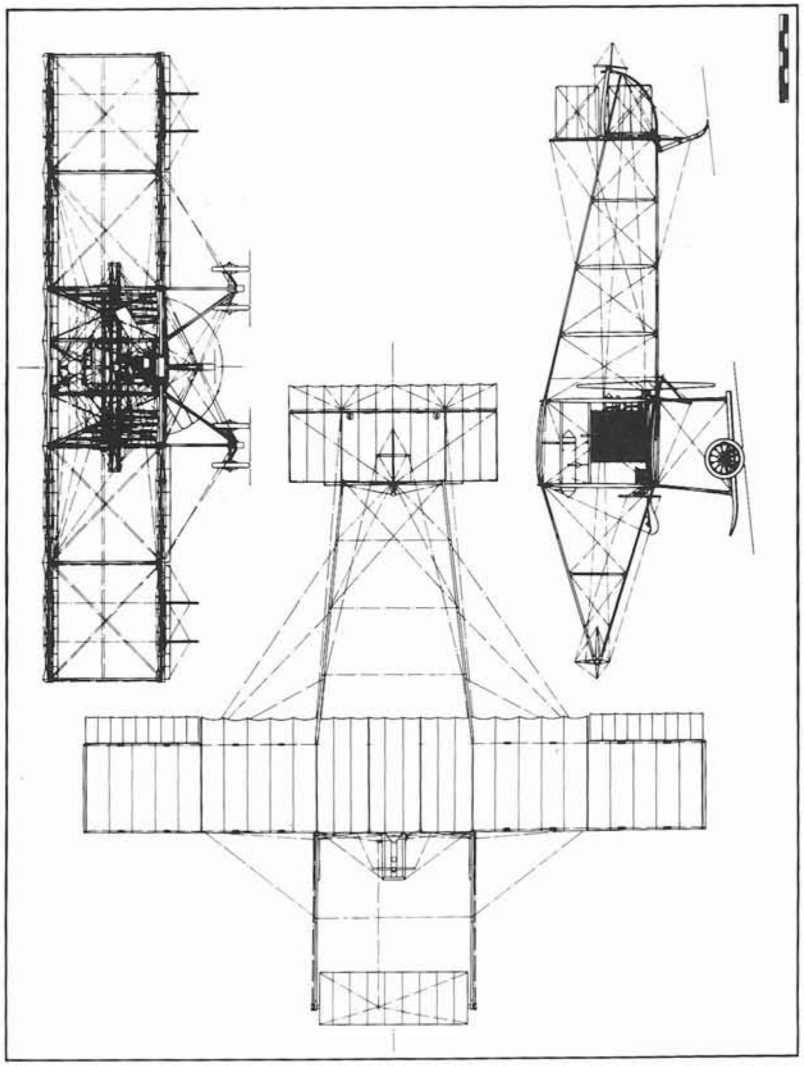
Howard Wright 1910 Biplane

The last and most successful aircraft built by Howard Wright to W.O. Manning's design were the 1910 Biplanes. On many occasions these were likened to and confused with the Farman Biplane but in detail design and workmanship they were incomparable. Further recognition of the attributes of the 1910 Biplane was achieved through the exploits of its pilots, who found it pleasant to fly and tolerant of mishandling.

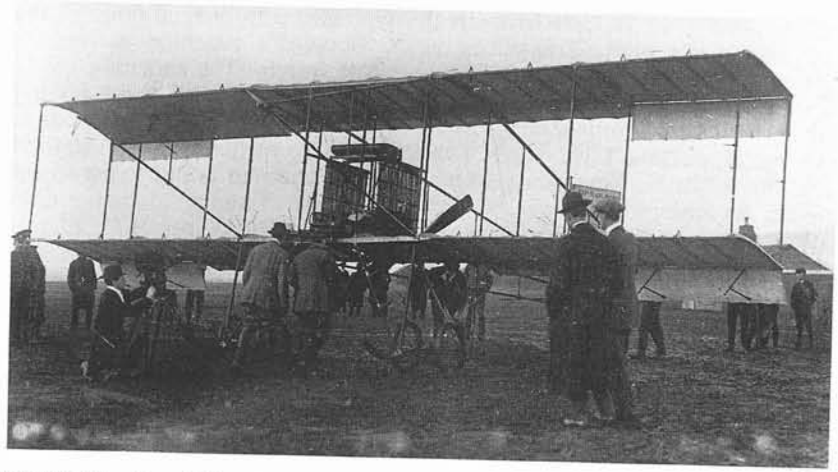
The aircraft closely followed the pattern for a two-seat pusher biplane introduced by Farman and emulated by many others, with the pilot and passenger seated in tandem in an exposed position over the leading-edge of the lower wing and in front of the engine. Initial versions of the machine were fitted with a 60 hp ENV vee-eight water-cooled engine, its radiators flanking the passenger, but at a later date the aircraft were fitted with a 50 hp Gnome rotary engine. Propellers of Howard Wright manufacture were fitted to all 1910 Biplanes.

The parallel-chord wings were built up on two spars, one spar being positioned along the leading-edge and the other at the aileron hinge line. Both spars were braced along their length with wires passing through the apexes of small sheet-steel inverted-V posts. The upper wing could be increased in area by detachable extensions braced from a kingpost at the leading edge near the joint. Ailerons were mounted on all four wingtips and the extensions when fitted, and were operated from a column placed at the pilot's right-hand side. The pilot's control column was connected, also, to the forward elevator which in turn was linked directly to the tail elevator, and the split rudder was pedal operated. The monoplane tail, built and braced in a similar manner to the wings, could be adjusted on the ground for changes of trim and was carried, like the forward elevator, on four wire-braced booms. The bracing wires in the region of the propeller, however, were prevented from flying about, in the event of breaking or coming adrift, by being tied at intervals to cords running parallel with them. The undercarriage was the accepted arrangement of wheels and skids. A large proportion of the airframe was made from Honduras mahogany, ash being used only in the undercarriage and for the rudder post. Fittings were made from cast aluminium and steel, and where attachments had to be made the wooden parts were locally reinforced with steel plate. Although production of the biplane was continuous over a period of about a year and each machine was constructed to a common pattern, no two aircraft were identical, modifications being made to suit the customer's individual needs.

The biplane, fitted with upper wing extensions, made its début at Larkhill, Salisbury Plain, during August 1910, piloted by Lieut E.M. Maitland, who had qualified for his brevet in France. Shortly after taking delivery of the machine, Maitland crashed it at Larkhill. His injuries prevented him making further flights but he had the machine repaired and lent it to his brother officer, Lieut H.E. Watkins, so that he could learn to fly. Watkins took the aircraft to Brooklands and there used it to qualify for his Royal Aero Club Aviator's Certificate, No.25, on 15 November, 1910. On his first circuit of Brooklands, Watkins flew with Manning as his passenger. In December, Watkins took the biplane to Shorncliffe, near Folkestone, to compete for the Baron de Forest prize but the aircraft was wrecked before he could start. The biplane had been fitted with an automatic wireless transmitter so that Watkins' flight could be tracked by Maitland from a tug equipped with a receiver as they crossed the English Channel. After repairs, the biplane was flown on a number of occasions before Maitland sold it to the War Office for £625 on the opening day of



Howard Wright 1910 Biplane (Sopwith's Aircraft).



Lieut Maitland's and Lieut Watkin's Howard Wright 1910 Biplane on the occasion of being handed over to the Air Battalion of the Royal Engineers. (*via M. H. Goodall*)

the 1911 Olympia Aero Show. It was officially taken on charge on 23 June, 1911, and given the serial number F3. The aircraft served with No.2 Company, the Air Battalion of the Royal Engineers, at Larkhill, and accumulated 1 hr 56 min flying time before becoming unserviceable on 8 July, 1911. In the following January, it was taken to the Royal Aircraft Factory, Farnborough, and used, ostensibly, in the construction of the B.E.6, serial number 206.

After the sale of Maitland's biplane, Watkins bought another of the same type from John Dones, better known as 'Jack Dare', who was the brother of the then well-known actress sisters, Zena and Phyllis Dare. Dones' biplane was the second to be built and was delivered to him at Eastchurch at the end of September 1910. This aircraft was also owned at a later date by W.D. Johnstone.

T. O. M. Sopwith's Howard Wright 1910 Biplane undergoing repairs to an aileron at Brooklands. (*via M. H. Goodall*)

The third 1910 Biplane brought the type into prominence through the exploits of its pilot, T.O.M. Sopwith. Sopwith's machine arrived at Brooklands in November 1910, from Eastchurch. The morning of 21 November saw Sopwith attempting a few straight flights without having taken any instructions on handling, and in the afternoon he made a number of circular flights, which included three to qualify for Aviator's Certificate No.31. Three days later, and with only ten hours flying to his credit, he entered the biplane for the British Empire Michelin Cup competition for the longest nonstop flight by a British pilot in a British machine. Sopwith's flight from 10.15 am to 1.18 pm covering 107 miles not only set up new British records but also put him in a strong position to win the prize. The next two weeks were spent in modifying the ENV-powered standard pattern biplane for longer flights. The modifications included: adding upper wingtip extensions with ailerons; fitting a large-capacity petrol tank in place of the passenger's seat; the addition of a fabric-covered fairing for the pilot's protection; and repositioning the control column to between the pilot's legs. On 18 December, the Baron de Forest prize was Sopwith's with a flight of 169 miles in $3\frac{1}{2}$ hr from Eastchurch to Beaumont in Belgium. Sopwith's biplane also gained the distinction of being the first all-British aircraft to be flown across the English Channel. As 1910 drew to a close, Sopwith set out to improve his time for the Michelin Cup and on 31 December, the last day of the contest, established a new record of 4 hr 7 min 17 sec with a flight of 150 miles 246 yards. However, the prize was not to be his, S.F. Cody claimed it at the last moment with a flight of 195 miles in 4 hr 50 min.

On 1 February, 1911, Sopwith flew his biplane to Windsor Castle at the invitation of HM King George V, a journey made from Brooklands in thick mist and intense cold. In April, the biplane was displayed on the Royal Aero Club's stand at the Olympia Aero Show before being taken by Sopwith, in the following month, to the USA. Sopwith's tour of the USA proved extremely successful, many passenger-carrying, demonstration and stunt flights being made interspersed with competitive flying. The tour, however, was not without mishap, the biplane being wrecked on two occasions; at Columbus, Ohio, on 3 June, when Sopwith skimmed low over a field and the starboard undercarriage skid dug into a small hillock, and near Manhattan Beach, on 10 September, when the engine failed and Sopwith and his passenger came down in the sea. The biplane was repaired after both accidents! On his return from the USA, Sopwith established a school of flying at Brooklands and used the biplane for training, for which role it had been fitted with dual control in March 1912.

The next ENV-powered biplane was exported unassembled to New Zealand in 1910. It had been bought by two Auckland brothers, Leo and Vivian Walsh, with the backing of an enthusiastic syndicate. They, with the aid of their sisters, completed the biplane late in 1910 and, after initial tests during which Vivian Walsh had to teach himself to fly, the biplane was given its first public demonstration before New Zealand's prime minister at Papakura on 5 February, 1911. About a year later, the biplane was taken over by W.S. Miller and F.E. Sandford, who rebuilt and modified it to have sweptback outer-wing panels and a semi-enclosed cockpit. The biplane was tested in its new form at Avondale Racecourse, Auckland, in February 1913. It subsequently made a number of successful

Howard Wright 1910 Biplane bought and assembled by the Walsh brothers at Auckland, New Zealand, in 1911. (*Alexander Turnbull Library, Wellington, New Zealand*)

flights but was finally written-off after a crash at Alexandra Park, Auckland, on 6 December, 1913. The only other biplane, fitted with an ENV engine, known to have been flown abroad was that owned by W.C. England at Rangoon during the summer of 1912.

At home, the 1911 Olympia Aero Show heralded a new variant of the biplane. Although it followed the original pattern, the layout was adaptable for racing for which purpose it had been built for Robert Loraine, the Irish actor who had achieved fame with his crossing of the Irish Sea in the previous September. The biplane was powered by the 50 hp Gnome rotary engine salvaged after the crossing from Loraine's Farman racing biplane, and it was the first time that this type of engine had been used in any Howard Wright machine. To adapt the aircraft for racing the lower wings could be reduced in span by removing their outer sections. This was accomplished simply by releasing ten bracing wires, undoing two bolts and removing two struts from their sockets at each wingtip. Alterations to the controls were avoided by the fitting of broad-chord ailerons only to the upper wing. The only other noticeable difference, a minor one, was the fitting of undercarriage skids which had their forward portions more upturned than usual. After the Show the aircraft was flown at Brooklands.

The second Gnome-powered biplane, also a racing pattern, was bought by Claude Grahame-White, who flew it during the latter part of 1911 at Hendon. During 1912 Grahame-White used the biplane for training at his newly established flying school and at which, on 6 June, no less than six pilots used it to qualify for their aviator's certificate, among them No.231 awarded to Marcus Dyce Manton, who was later to become chief test pilot and inspector to The English Electric Co. The others were: H.C. Biard, F.H. Fowler, T.O'B. Hubbard, R.T. Gates and Lieut B.T. Janes. Two weeks later N.S. Roupell and E.H. Morriss gained their brevets. The last to qualify on the biplane was R.H. Kershaw on 16 July. In the meantime Grahame-White had married Dorothy Taylor, whom he had met in New York. On this occasion the biplane was flown by the bridegroom to the reception held at Sir Daniel Gooch's mansion, *Hylands*, at Widford in

Hertfordshire. Seven days later, on 6 July, the biplane was flown by Lewis Turner to win the speed handicap race at Hendon. In July, also, Turner crashed the biplane at Harlow, Middlesex.

The last two biplanes to be built were entered for the £10,000 *Daily Mail* Circuit of Britain race and the second Michelin Cup competition respectively. The former machine was fitted with upper wing extensions, a small bluff fairing in front of the pilot and 60 hp Green engine. It was flown by Lieut H.R.P. Reynolds who, although delayed by previous competitors for the race, made a good start in the evening of Saturday, 22 July, 1911. Reynolds landed at Hendon that night. He spent Sunday adjusting the engine to give more power and making several circuits to test its performance. On Monday he rejoined the race, reaching Doncaster by nightfall. Reynolds arrived at Harrogate the next day but there was forced to retire from the race. J.L. Longstaffe, the pilot of the other machine fared little better, his attempts at the Michelin Cup being thwarted by mechanical trouble.

Records show that Capt G. Ll. Hinds Howell and one Louis de Silva also piloted the biplane at Brooklands during 1910. Production of the biplane, however, ceased with the sale of Howard Wright's aircraft interests to the Coventry Ordnance Works.

1910 Biplane (Standard pattern)

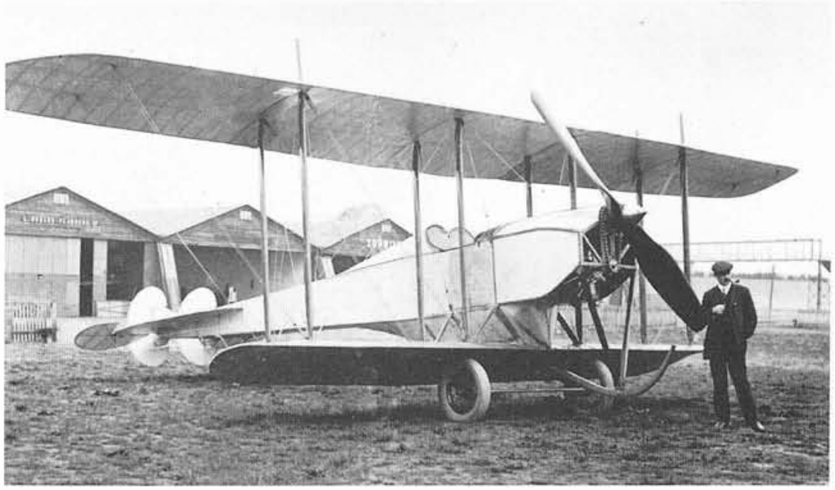
Span 36 ft; span upper wing with extensions 48 ft; length 36 ft 6 in; height without wing extensions 12 ft; wing chord 6 ft 6 in; gap 6 ft 6 in; aileron span 6 ft 6 in; extension aileron span 6 ft; aileron chord 1 ft 6 in; forward elevator span 8 ft 6 in; forward elevator chord 3 ft; tailplane span 12 ft; tailplane chord including elevator 5 ft 6 in; elevator span 12 ft; elevator chord 1 ft 6 in; rudder height each 2 ft 6 in; rudder chord each 3 ft; propeller diameter 8 ft; propeller pitch 4 ft 8 in; wing area including ailerons 454 sq ft; wing area with extensions including ailerons 532 sq ft; total aileron area 39 sq ft; total aileron area with extensions 57 sq ft; forward elevator area 25.5 sq ft; tailplane area including elevator 66 sq ft; elevator area 18.5 sq ft; total rudder area 15 sq ft.
Weight empty 800 lb; weight loaded 1,200 lb.
Maximum speed 45 mph; cruising speed 36 mph; endurance 5 hr.
Price £1,000.

1910 Biplane (Racing pattern)

Span upper wing 36 ft; span lower wing 22 ft; length 37 ft; wing chord 6 ft; gap 6 ft.

Coventry Ordnance Works Military Trials Biplanes

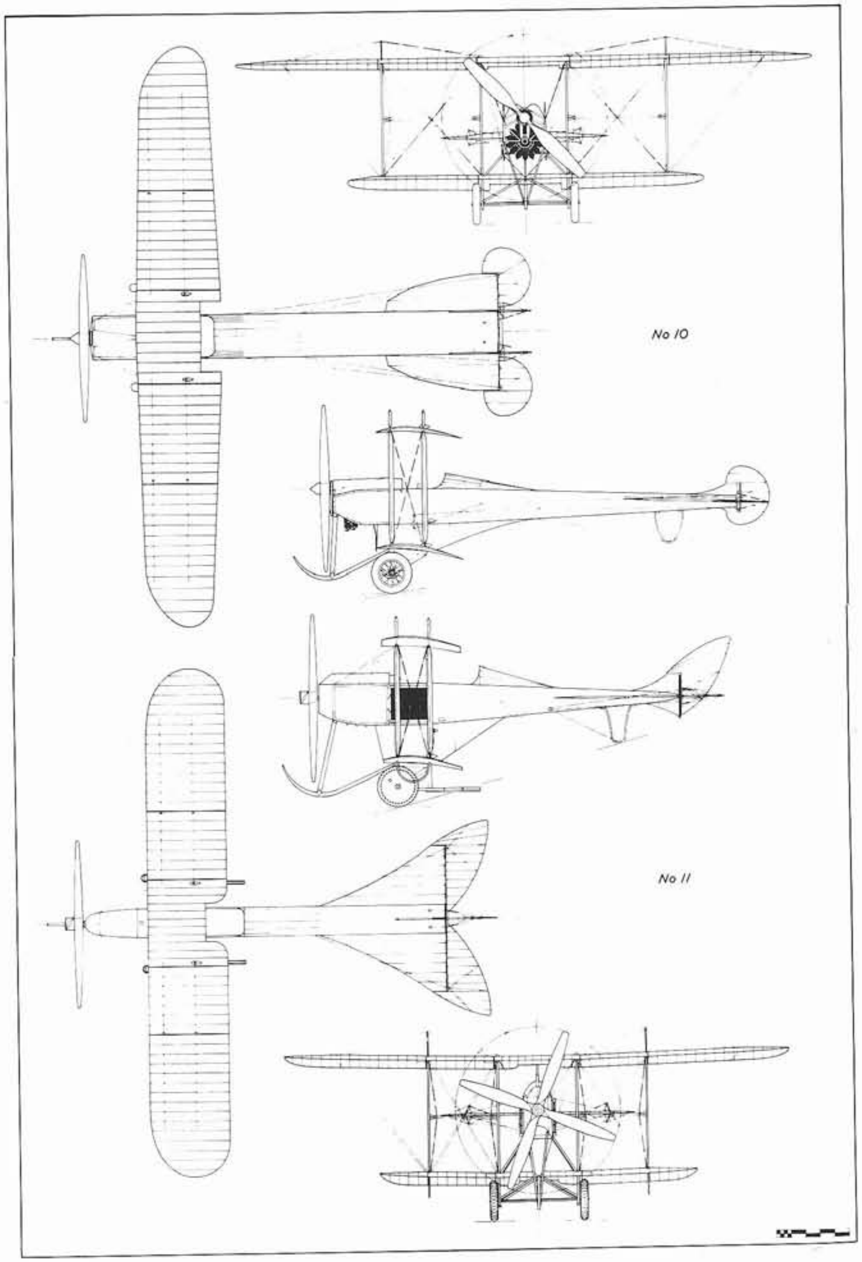
During the summer of 1911, Col J.E.B. Seely, Under Secretary for War, announced that the War Office was considering offering prizes for an aeroplane suitable for military use. By October, plans for a competition were being formed, and early in December, an Aeronautical Society meeting, held at the Royal United Services Institute, London, provided an opportunity for open discussion between the Army and aircraft



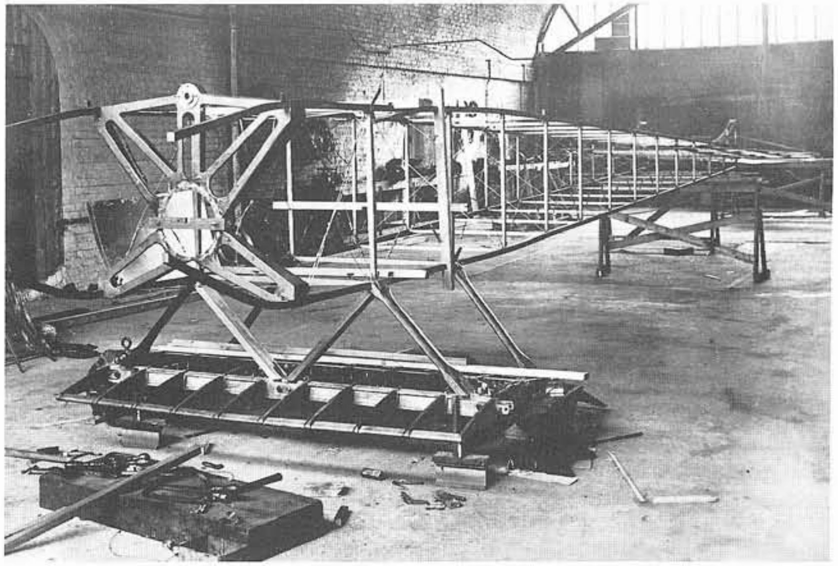
COW's entry for the 1912 Military Trials, later given Trials No.10, making its début at Brooklands in April. Note the early form of the wings without centre-section cut-outs. (*M. H. Goodall*)

constructors regarding the requirements of military aircraft. Among those present at the meeting were W.O. Manning and Howard T. Wright, representing the Coventry Ordnance Works Ltd, which had just taken over Wright's business under the railway arches at Battersea. The meeting proved so successful that a second one was arranged but before this took place the War Office announced the conditions and prizes for its competition to be held at Larkhill in August 1912. The directors of the Coventry Ordnance Works, on hearing the details of the competition, decided to enter aircraft for what became known as the Military Trials and accordingly authorised Manning and Wright to proceed with the design and manufacture of suitable machines.

Manning set to work immediately after the decision had been made and soon produced two designs, both of unequal-span tractor biplanes, one having its two crew seated side-by-side and the other with its two crew seated in tandem. Powerplants chosen were the 100 hp Gnome, fourteen-cylinder rotary and the 110 hp Chenu inline water-cooled engine. Their installation was decided from consideration of frontal area, and the Chenu engine was therefore fitted to the tandem-seat design, which had a narrow fuselage with a short rounded top-decking immediately behind the open cockpit. The fuselage of the Gnome-powered biplane was untapered in plan and necessarily broad but tapered rearwards in side elevation, two faired head-rests being provided for the crew. Both machines had their fuselages mounted above the lower wing, which was attached at its centre-section by four pairs of short struts, the centre pairs forming a framework for a streamline fairing that enclosed the petrol tank. The upper wing of each biplane was carried solely by four pairs of interplane-struts and was made in five sections. The outboard sections of the upper wing were braced from kingposts and could be warped for lateral control. The wings of the



Coventry Ordnance Works 1912 Military Trials Biplanes.



Fuselage for Biplane No. 10 under construction at Battersea early in 1912.

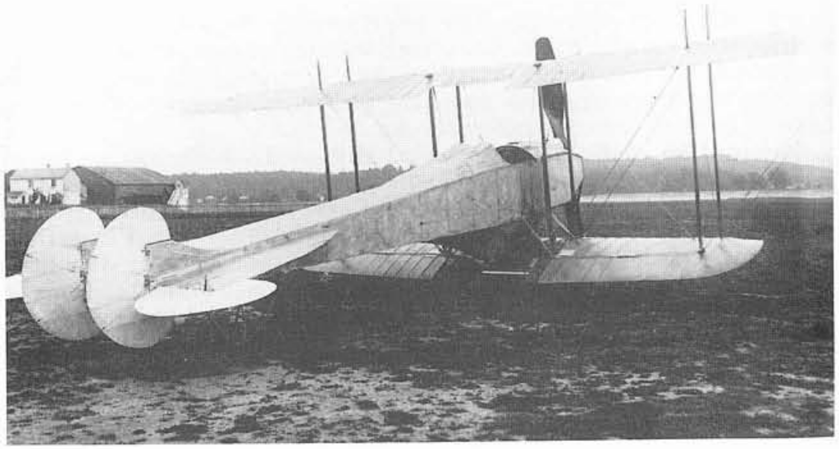
Gnome-powered biplane were tapered in plan and those of the other machine were of parallel chord. There was no centre-section cut-out in either wing of the Gnome-powered aircraft when it first appeared at Brooklands but they were incorporated within a month of its début. The fixed tail surfaces of the Gnome-engined aircraft were semi-elliptical in planform, and those of the other of triangular shape. The elevators, fin and rudder of the two machines were distinctive in arrangement. The Gnome-powered biplane had three-quarter circular elevators, with the forward quarter forming a horn-balance, small twin triangular fins, each mounted in line with the fuselage sides, and twin elliptically-shaped rudders, which each had two horn-balances. The Chenu version had a single triangular fin and horn-balanced rudder and elevators of shark's fin shape. Each machine's undercarriage was unsprung and relied upon its low-pressure balloon tyres to absorb landing shocks.

Construction of the Gnome-powered Military Trials Biplane started at Battersea early in 1912 with the manufacture and assembly of its fuselage, the metal fittings for which were made at COW's factory at Coventry. The fuselage was a wire-braced box-girder structure with four ash longerons and spruce spacing-struts. The forward ends of the longerons were bent using steam and fitted into two steel pressings, which carried the engine and propeller shaft, the latter being mounted above and driven by a $1\frac{1}{2}$ in Renold roller chain through a 2:1 reduction gear from the engine. The Gnome engine was fitted with Bosch dual ignition and could be started from the cockpit. Nine laminations of teak were used for the Manning-designed two-blade propeller, the inner region of which gave low thrust to reduce drag and pilot discomfort from the slipstream. The propeller hub had the additional refinement of a spinner. Engine and nose fuselage

cowling was cut from sheet aluminium and attached by means of car-hood fasteners. A 10 Imp gal gravity petrol tank and a 22 Imp gal oil tank were carried in the bay behind the engine, the gravity tank being supplied with fuel pumped from the 40 Imp gal tank carried in the fairing between the fuselage and lower-wing centre-section.

Pilot's controls comprised a wheel at the top of a pivoted control column, and a rudder bar. Dual rudder control was later installed. Both wings were built-up on two I-section ash spars and a thinner intermediate spar, and had solid ribs of Eiffel No. 8 aerofoil section, lightened with holes between the spars. The fabric-covered wings were internally braced by wires, inspection of their joints and those of the spars being made through sliding aluminium panels. Interplane-struts and kingposts were of streamline section and made from silver spruce. Stranded cable was used for external bracing and warping wires, the latter passing through pulleys housed in streamline fairings. All tail surfaces had flat wooden frameworks and were fabric covered. Undercarriage and nose skid struts were made of Honduras mahogany, the skid itself being of hickory. A small tusk was fitted inboard of each spoked wheel to prevent the apex of each undercarriage leg from digging into the ground in the event of the spokes breaking. The tailskid was of bent cane and was fitted with a simple but effective braking device, comprising a spring-steel claw which was always operative unless drawn clear of the ground by the pilot pulling the wire attached to it and fastening this to a hook near his seat.

About the end of April 1912, the components of the Gnome-powered biplane were taken to Brooklands and there assembled in hangar No.32, which had also been taken over by COW from Howard Wright. Its début at Brooklands created considerable interest and an aviation journalist writing for *Aeronautics* was later to record: 'In strength, in neatness and finish of design, in minute attention to detail, nothing finer than this splendid biplane has ever been produced in the country.' The biplane's first flight was made shortly afterwards by T.O.M. Sopwith, whose services as test pilot had been secured by COW. The flight was successful, Sopwith



Biplane No.10 at Brooklands. Note revised wing form.

being particularly impressed by the machine's remarkable rate of climb, and was soon followed by a second with Manning as passenger. On the following day, the biplane was entered for an impromptu take-off competition and cross-country race held at Brooklands, Sopwith taking three passengers aloft for the first event, two of the passengers sitting at each side of the fuselage on the lower wing. From this time the biplane was nicknamed, *Wombus* (W.O. Manning's omnibus). The biplane was flown throughout the summer in preparation for the Military Trials but persistent trouble was experienced with the chain drive to the propeller, which resulted in the fitting of three 1-in roller chains instead of the single chain. Elevator area was also found to be inadequate and was increased.

With the completion of the first COW biplane, construction of the Chenu-powered version progressed more quickly but this was not delivered to Brooklands until July 1912, when it was tested by Sopwith. The second biplane's structure was similar to the first, changes being dictated by the biplane's configuration only. Besides having a smaller span, the fuselage was shortened by the removal of one bay behind the cockpit. The fuselage was also mounted higher in the wing gap since the propeller was directly driven and propeller ground clearance had to be maintained without lengthening the undercarriage legs. The Chenu engine was fully cowled and its radiators were mounted on each side of the forward cockpit. A four-blade propeller, made from a pair of superimposed two-blade propellers, was fitted, this somewhat unusual arrangement possibly arising from the transport and crating requirements of the Military Trials, although Manning may have considered the economics of being able to replace one two-blade propeller in the event of damage. The only other noticeable changes were the fitting of two short skids behind the undercarriage wheels and skids below the lower wingtips.

The first COW Biplane, which had been allotted Trials No.10, arrived at Larkhill in good time for the start of the Military Trials but its sister machine, given Trials No.11, had not reached Larkhill by 31 July, the stipulated deadline for all competitors. It had been delayed in its journey

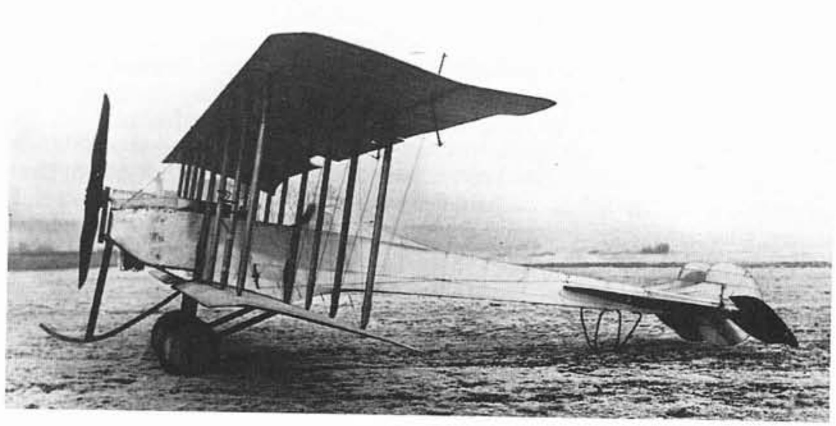
Biplane No.10 at Larkhill in August 1912. (*Leslie/Bruce Collection*)

Biplane No.11 with pilot and ground crew at Larkhill. (*T. L. Fuller*)

by road but despite its late arrival, was not disqualified from the competition. The Trials included twelve tests of which No.10 attempted only the first three, covering constructional requirements, quick assembly tests and the three-hour test, and No.11 failed to compete owing to engine trouble. In the quick assembly test No.10 came fourteenth, five men taking 1 hr 51 min 45 sec to assemble the biplane ready for flight. The three-hour test was attempted on 22 August with F.P. Raynham at the controls but was abandoned after one hour when he was forced to land owing to a leak in the pressure pump, which transferred fuel from the ventral tank to the gravity tank. Further trouble with the propeller of No.10 prevented it from entering more of the tests. Unfortunately, Manning was abroad at the time these difficulties were encountered, and it was not until his return, late in August after the Trials, that he was able to investigate the faults. Howard Wright had left the Coventry Ordnance Works, about this time, to become chief designer to J. Samuel White & Co Ltd, of Cowes.

Further test flights with No.10 made at Brooklands, where both biplanes returned after the Trials, were unsatisfactory and led Manning to modify the machine using as many of the original components as possible. The modified biplane bore a slight resemblance to No.10 owing to the use of the latter's fuselage, fixed tail surfaces and rudder. The Gnome engine installation was retained but a new propeller of the same diameter was made. New wings of increased and unequal span and constant chord were fitted together with elevators of larger area. The upper-wing had inversely-tapered split ailerons and was carried by eight pairs of interplane-struts of reduced length, the lower-wing being attached close to the lower surface of the fuselage. The undercarriage legs were lengthened to maintain propeller ground clearance and again balloon tyres were used.

Reconstruction of No.10 was undertaken late in 1912 and the modified biplane was flown for the first time, by Raynham at Brooklands on 13 January, 1913. The new biplane proved more successful than the original but the chain drive to the propeller still gave trouble. A smaller diameter



Biplane No.10 Modified, Brooklands, January 1913.

two-blade propeller was fitted directly to the engine, and, at the same time, the engine cowling was reshaped by the addition of two rounded fairings on each side of the propeller attachment. Thereafter the biplane was flown successfully throughout 1913.

The fate of No.11 remains unknown.

No.10

Span: upper 40 ft, lower 24 ft 8 in; overall length 33 ft 3 in; height 12 ft 8 in; wing root chord upper and lower 6 ft; wingtip chord: upper 4 ft 6 in, lower 5 ft 2 in; gap 8 ft; tailplane span excluding elevators 8 ft; tailplane root chord 7 ft 10 in; elevator span: original 4 ft, final 5 ft 3 in; maximum elevator chord 3 ft 4 in; rudder height 4 ft; maximum rudder chord 3 ft; propeller diameter 11 ft 6 in; undercarriage track 6 ft 9 in; wheel diameter 2 ft 10 in; wing area: original 336.7 sq ft, final 319.7 sq ft; tailplane area excluding elevators 30.9 sq ft; total elevator area: original 17.3 sq ft, final 27.4 sq ft; total fin area 4 sq ft; total rudder area 15.6 sq ft.
Weight empty 1,200 lb; weight loaded 1,950 lb.
Maximum speed 60 mph; landing speed 20 mph.

No.10 Modified

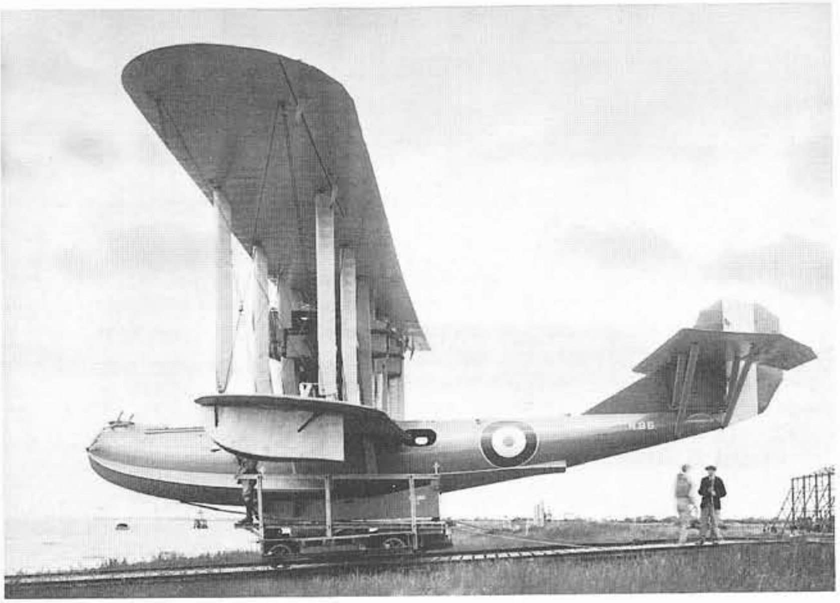
Upper wing span 56 ft; wing area 630 sq ft.
Weight empty 1,100 lb; weight loaded 1,900 lb.
Maximum speed 60 mph; landing speed less than 20 mph.

No.11

Span: upper 35 ft, lower 22 ft; overall length 31 ft 3 in; height 13 ft 2 in; wing chord upper and lower 5 ft 6 in; gap 8 ft; tailplane span excluding elevators 10 ft; tailplane root chord 6 ft 9 in; elevator span 6 ft 6 in; maximum elevator chord 4 ft; rudder height 5 ft 3 in; maximum rudder chord 4 ft 6 in; propeller diameter 11 ft 6 in; undercarriage track 6 ft 3 in; wheel diameter 2 ft 10 in; wing area 290.5 sq ft; tailplane area excluding elevators 35.8 sq ft; total elevator area 24 sq ft; fin area 4 sq ft; rudder area 10.8 sq ft.
Weight empty 1,250 lb; weight loaded 2,050 lb.
Maximum speed 68–70 mph.

Coventry Ordnance Works Admiralty Type 54

In 1913, the Coventry Ordnance Works received contract No. CP 40633/13 from the Air Department of the Admiralty for one seaplane. It was powered by a 160 hp Gnome rotary, and allotted serial number 54. The seaplane was fitted with wireless and allotted the call sign NO6 in August 1913. No record has been found of the aircraft in Service or ever being completed.



Cork Mk I N86 on the slipway at Brough. (*H. Bottomley*)

Phœnix P.5 Cork

On 31 October, 1917, a memorandum, signed by F.E.T. Hewlett on behalf of the Controller, Technical Department (TIN Section), was sent to Maj John Buchanan, Controller of the Air Board's Technical Department. The memorandum requested the Air Board's approval for a contract to be placed with the Phœnix Dynamo Manufacturing Co Ltd, of Bradford, for the design and construction of the aero-structure of two experimental F.3 flying-boats, whose hulls were then being built at May, Harden & May Ltd's Kingston Bridge Works at Hampton Wick on the River Thames. Approval was given under British Requisition No.256 and Sir William Weir, Controller of Aeronautical Supplies, was notified of the Board's decision on 12 November. Three days later, Phœnix was instructed to

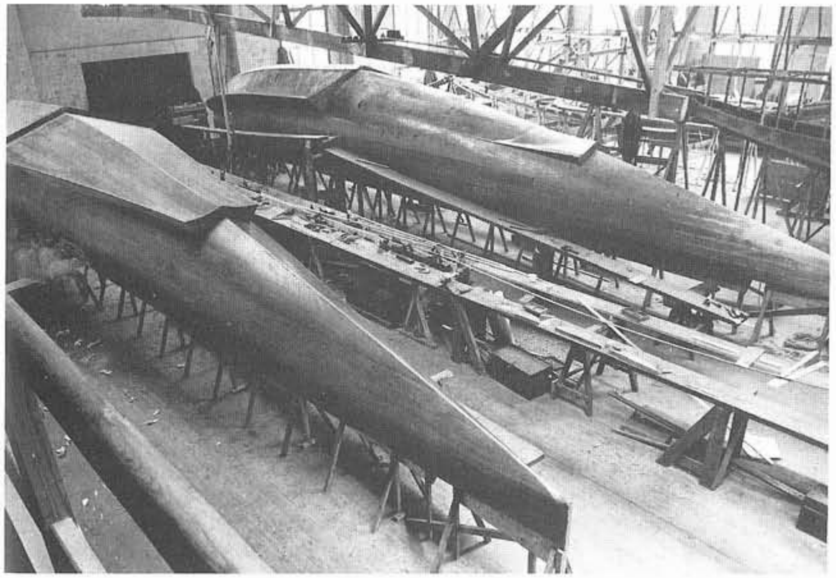
proceed not only with the design of the aero-structure but also with preparations for the production of the complete aircraft. Drawings of the hulls were forwarded and Phœnix was particularly requested to:

'1) Increase the aerodynamic efficiency of the present machine [the standard F.3], keeping the wing roots exactly the same as the present machine in order that the aerial structure should be interchangeable with standard design.

2) Simplify the design of the machine in order to facilitate production.'

The contract, No. AS 37016/17, was signed on 28 November and the two flying-boats were allocated serial numbers N86 and N87. Phœnix gave the flying-boats the designation P.5, the appellation Cork not being used until about June 1918 after the issue of Technical Department Instruction 538 (later to become AP 547) regarding aircraft nomenclature. The Cork came in the category of aircraft with more than one engine and of 11,000–20,000 lb all-up weight to be named after seaboard towns in Scotland and Ireland.

The P.5 was the result of an Admiralty decision to build a large twin-engine flying-boat to meet specification N.3B (later known as RAF Spec XXX), which the Admiralty's Air Department had formulated early in 1917, for an anti-submarine patrol machine of similar displacement to the Porte-designed Felixstowe flying-boats. The Admiralty decided also that the P.5 should have a hull designed by Lt Cdr Linton C. Hope, and authorised May, Harden & May to build two hulls to his principle of monocoque construction. This type of structure proved to be remarkably strong, yet resilient, and enabled the hull to have good streamline form. Generally, the Linton Hope hull was covered by two thin layers of narrow planks, the inner layer usually being wrapped diagonally and the outer laid



P.5 (foreground) and P.5A hulls under construction at May, Harden & May's Kingston Bridge Works. (*Leslie/Bruce Collection*)

longitudinally, rivetted to closely-pitched hoops attached to numerous stringers, which were in turn fastened to almost circular hoop frames, the whole being built up on a keel that ran from stem to stern. The planing bottom was added separately and was similarly constructed.

Manufacture of the hulls, which were not identical, started towards the end of 1917. The first hull appears to have been completed shortly before 11 April, 1918, when Maj A.J. Miley, Assistant Controller, Technical Department (Design), informed Phœnix of the measured weight and position of the centre of gravity of the hull, and the second a little later. The first could be distinguished from the second by its planing surface, which, although discontinuous at the main step, extended aft to the rear step: the second hull had only a forward planing bottom and small rear step faired to the basic hull, the chine-line of the rear step being formed by a strake that was continuous with the top of the fin deck of the forward surface. (In R & M No.461: *The Resistance of Flying Boat Hulls*, published in July 1918, the first hull was numbered P.5 and the second, P.5A. This nomenclature was also used, though not widely, by Phœnix who applied the designations to N86 and N87 respectively. The order in which the hulls were eventually to be used however, was reversed, the P.5 hull being fitted to N87 and vice versa). The basic structure of both hulls was identical and each had openings in the upper surface for the bow gunner, pilot and co-pilot, who were seated in tandem, and the engineer. There were also two gunners' waist-hatches closed by detachable doors which had glazed portholes, although Linton Hope had, at one stage, considered a single cockpit on top of the hull for the rear gunner. Holes were also provided in the top-sides of each hull for the spars of the lower-wing centre-section. The hull's covering consisted of two layers of mahogany planks separated by a layer of varnished fabric for water proofing. The outer planks were laid longitudinally and were $\frac{5}{32}$ in thick and the inner were wrapped diagonally and were $\frac{5}{16}$ in thick, the whole being rivetted with copper nails and roves to $\frac{3}{8}$ in square spruce timbers or hoops spaced $1\frac{3}{4}$ in apart. These had their ends let into the rock elm keel and were glued to 35 stringers of $1\frac{1}{2}$ by $\frac{1}{2}$ in spruce, distributed evenly around the periphery of the hull and attached to almost circular frames placed at intervals of 2–3 ft. The frames were fastened directly to the top of the keel and were steam-bent from a length of rectangular-sectioned rock elm, joints being scarfed and made alternately at the top and bottom of the hull. The lower part of the hull was reinforced by short transverse strips of square-sectioned spruce, known as floors, which passed through the keel. Each hull's forward planing bottom had two mahogany skins separated by varnished fabric, the inner diagonal planking being $\frac{3}{32}$ in thick and the outer $\frac{3}{16}$ in, and fastened to a structure similar to that of the basic hull but with plywood transverse bulkheads, which created a number of watertight compartments. The rear planing bottom of the first hull was built in a similar manner, the thickness of its inner and outer planking being $\frac{5}{64}$ in and $\frac{5}{32}$ in respectively. That fitted to the second hull was little more than a fairing to the rear step but was also of Linton Hope construction.

The first hull was delivered by road from Hampton Wick to Bradford before the end of April 1918, and was followed soon afterwards by the second, its journey northwards beginning on Wednesday, 8 May. Total production time for the two hulls was recorded as 31,348 man-hours.

Meanwhile, on 9 April, May, Harden & May had delivered models of the hulls, which they had made to contract No. 38A/167/C.160 at a cost of £26-8-0 each, to the Technical Department, where they were received by Linton Hope himself. These models were then made over to the NPL and used for comparative wind-tunnel tests, the results obtained being published in R & M No.461. The tests revealed that the first or P.5 hull had considerably less drag at all speeds than the second or P.5A hull. A modified P.5 hull, in which the fin deck was faired to the basic hull by a concave fillet, was also tested. It too was found to have less drag than the P.5A and was even marginally better than the original form. Despite the P.5's superiority, which would have been reflected in the performance of the complete flying-boat, it was stored on arrival at Bradford and the P.5A hull used in its place. The reason for this change remains obscure but possibly it had its origin as early as November 1916, when R & M No.300: *Experiments with Models of Seaplane Floats, Eleventh Series* was published. This report gave details of hydrodynamic tests conducted at the NPL on a model hull, similar to the P.5, supplied by Linton Hope. Various alterations were made to the hull and the form which was finally evolved was similar to the P.5A. This hull had better seaworthiness characteristics in that side waves created by the forward planing bottom finished as fan-shaped sprays clear of the stern. Previously, heavy spray was thrown up well above the top of the hull by the forward surface and the side waves tended to curl in and over the rear portion of the hull, with consequent saturation of and damage to wings and tail surfaces if they were set too low. It would appear that the P.5 hull was passed over in favour of the P.5A because of the former's poor seaworthiness. That the P.5 hull was built suggests that comparative full-scale trials were to be performed.

At Bradford, in the spring of 1918, the aero-structure, which had been designed by W.O. Manning, was nearing completion. Its design had been done under the supervision of the Technical Department, which had checked and approved Manning's calculations and had made recommendations where necessary. An instance of this had occurred on 11 March, 1918, when Solly Brandt of the Structures & Stability Section had reported to Cdr Alec Ogilvie, Controller, Technical Department (Design), on the strength of wing spars, interplane-struts and bracing-wires, which, with the exception of a few control wires considered under strength, were found satisfactory. In accordance with Phœnix policy, that had resulted in the book *Women on munitions of war* being written by P.J. Pybus, Phœnix's managing director, at the instigation of the Prime Minister, Lloyd George, all parts of the flight structure were designed to enable female labour to be used wherever possible. This policy was applied to the manufacture of wood and metal components. Of the latter, fabricated items were reduced to a minimum, others were designed with mass-production in mind, and, in general, fittings and bolt sizes were standardised so that most parts were readily interchangeable and the variety of stores could be kept to a minimum.

The unequal-span wings were made in sections: the upper wing in three, of which the outboard were braced from faired kingposts above the outermost interplane-struts, and the lower in four, of which two formed the lower centre-section, since on N86 the spars passed through the hull. Although a similar arrangement had been envisaged for N87, this section

was built in one piece and attached directly to the top of the hull, the joint incorporating a streamline fairing. Each wing section had two box-spars made entirely of spruce and consisted of booms separated by distance pieces and webs joined to them by glue and screws. To reduce wastage the webs could be made from a number of short lengths spliced together, the number of splices, however, was strictly controlled. Ribs of RAF 14 aerofoil section were, in general, of Warren-girder construction and built from strips of spruce but those at the wing joints were fret-sawn from plywood and were lightened by elongated holes cut in them. Three-ply birch was used to cover the lower-wing leading-edge, to protect it from spray damage, and also the lower centre-section walkway used mainly by the engineer to start and tend the engines. Internal wing-bracing was by means of wires and tubular-steel struts, the ends of the latter being located solely by sockets in the spar fittings. Interplane and engine-struts were made of thin-walled steel tubes which had their ends sweated into and rivetted to socket attachments and which were faired by a fabric-covered wooden framework with three-ply leading edge. Reinforcing pieces of walnut or mahogany were fitted to the spars in way of connections for all struts and external bracing-wires, which were also of streamline section. Both wings were covered with fabric laid diagonally in broad strips and stitched to the ribs in the normal manner. Ailerons were fitted to the upper-wing only: each aileron was made in two parts to cater for wing deflections and was hinged to a secondary spar placed at a short distance behind the rear spars. The wingtip floats of N86 were identical to those fitted to the Felixstowe F.3; N87's were a little deeper.

The tailplane was of similar construction to the wings but had an inverted RAF 15 aerofoil section and was made in two parts joined on the centre-line, each half being braced to the hull by four faired tubular-steel struts. Three-ply was used instead of spruce for the spars' webs otherwise the materials used were the same as for the wings. Tailplane incidence could be varied on the ground by relocating the two bolts that joined the rear spar and passed through the rudder post. A horn-balanced rudder of composite wood and steel tube construction and of characteristic shape was fitted. The fin was readily detachable for covering and transport, having a diagonal box-spar which passed through the hull top and was joined to the keel by one bolt.

Two 360 hp Rolls-Royce Eagle VIIIs were specified for and installed in each flying-boat, the engine mountings being similar to those used on the Felixstowe machines. Both engines were fully enclosed in cowlings made of flat wooden-backed aluminium panels. Three main fuel tanks were situated beneath the centre-section: the forward and transverse tank contained 80 Imp gal of petrol and the others 120 Imp gal each. All tanks were of the same diameter, and baffles, sumps and pipe connections were made alike. Two wind-driven Rotoplunge pumps delivered the petrol to two 20 Imp gal gravity tanks carried below the upper centre-section. The petrol system was duplicated so that either or both engines could be run from either gravity tank. The engine throttle control was the subject of British patent No.122,996 filed by Manning on 17 July, 1918. It consisted of a single lever connected by short cranks to two pulleys around which were wrapped the control wires to the engines. When the lever was pushed straight forward both throttles opened simultaneously and if it was moved

to the right, the port engine was given more throttle than the starboard and vice versa.

The basic armament of both flying-boats was four 230 lb or two 520 lb bombs carried below the lower wing roots and five Lewis guns, one at the bows on a Scarff ring, one each for pilot and co-pilot on either side of their cockpits on rail mountings, and one on a gallows mounting at each waist hatch. N87 had in addition two small nacelles fitted to the trailing-edge of the upper wing, each equipped with one Scarff ring-mounted Lewis gun and to which the gunners gained access by climbing the steps on the innermost rear interplane-struts. In August 1918, Phœnix were asked to study the possibility of carrying 520 lb bombs sunk into the hull end of the lower wing in the event that the bomb load as planned came too near the water. Comments were also requested as to how four 520 lb bombs could be carried. These proposals came to nothing, however.

On 5 July, 1918, the Technical Department was notified of the completion of N86 and was asked for permission to erect the flying-boat at Brough, on the Humber Estuary. Exactly one week later another letter was sent stating that 'the P.5 [would be] ready for despatch very shortly'. Permission was given the following day and soon afterwards N86 was taken by road to Brough. Some parts, including the tail unit, various struts and engine cowlings, were delivered by rail, however. These were sent on 26 and 27 July. Before N86's completion, Phœnix had asked that Clifford B. Prodger be allowed to pilot the machine on its initial trials, to which the Technical Department had consented on 4 July with the proviso that Maj M.E.A. Wright would undertake subsequent test flights.

The first flight of N86, designated Cork Mk I, was made on Sunday, 4 August, 1918, between 6.24 and 6.33 pm by Prodger with Lt Cdr Hume, observer, and Capt Slater, engineer, both of whom represented the Admiralty. Two more flights were made before 8 o'clock that day, one of 8 minutes and the other of 28 minutes. All took place in fine weather with a Force 1 northeasterly wind blowing. Prodger reported that performance was 'very satisfactory'. He thought, however, that N86 was slightly nose heavy and that the rudder was too small. On account of the latter he did not attempt to fly at maximum speed. After the trials N86 was moored overnight on the mud of the estuary foreshore and brought in at 5.30 the following morning. Between then and the next test flight made on the evening of 9 August, the covering of N86's wings was found to have stretched slightly but this factor apparently made little difference to the test as it was reported to be a 'fine performance'. A new and enlarged rudder had been fitted for this flight which lasted 54 minutes and was made with N86 fully loaded. Prodger was again at the controls and his crew comprised Hume, Slater and Finch, an engineer from Rolls-Royce. The test was witnessed by Maj Maurice Wright and Maj Miley who were to be pilot and passenger respectively for the allocation flight to be made the following morning. This test began at 11.08 after some difficulty in starting the engines and was of 12 minutes duration. Because of the engine trouble another flight was arranged for the afternoon but it again proved to be a lengthy process starting the engines. By 4 o'clock, however, everything was in order but the tide was low. Nevertheless, a decision was made to proceed with the test. Unfortunately, just as N86 reached planing speed she struck a rock and started sinking, eventually grounding when half full of water. The

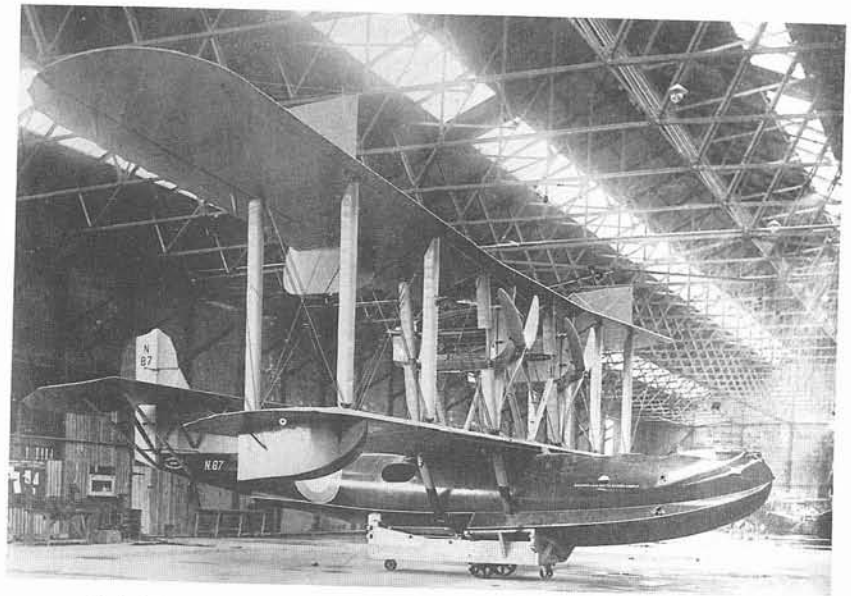
crew worked hard to restart the engines, which had stalled soon after the accident, succeeded in doing so, and were able to taxi the flying-boat shorewards to ground her on the mud. By that time it was 7.30 pm. Salvage operations could not be undertaken next day because Phœnix-built F.3 N4416 was launched and test flown leaving no time to attend to N86. The following morning, however, the hull was patched and the machine brought ashore. After repairs, N86 was flown by Maj Wright to the Marine Aircraft Experimental Station, Isle of Grain, on 24 August, 1918.

N86 passed final AID inspection at Grain the following day and during the ensuing week was test flown to obtain preliminary information of handling, climbing and speed, which was officially reported in NM 219, dated 31 August, 1918. Among the structural defects noted in the report was the slackness of the wing covering. Criticisms were made of the cockpit layout with regards to seats, instruments and throttle control, which was not considered as good as two separate levers capable of being grasped by one hand, this form being more familiar and natural to pilots. The criticisms, however, appear unjustified since, shortly after the hulls were delivered to Bradford, the cockpits were mocked-up using one of the hulls and their arrangement officially approved. The report continued: 'The machine is light on the lateral control and there appears to be sufficient [control]. It comes off a bank well. The rudder might be a little larger with slightly more balance and a higher gearing. The elevator is fairly light and effective. The machine is a little nose heavy. The boat is very stable in getting off and landing, no tendency to porpoise being noticed. A fair amount of water is thrown on the propellers when taxi-ing, and the bombs are washed by water thrown up by the fin [the outermost surface of the forward planing bottom], but not by a solid wave....The machine was taken off and landed in a slight lop. Apart from spray on the propellers the get-off was good, and the landing was very soft and free from shocks'.

An investigation into the cause of the slackness of the wing covering revealed that the type of dope used was unsuitable. As N87 was then under construction and its wings had been treated with a different dope, a decision was made to use them to replace those of N86. The exchange was effected in October 1918 and the original wings were sent back to Bradford for recovering and fitting to N87.

It was evident from the preliminary trials that the wings of N86 were set too low on the hull. This fact almost certainly led to the wings of N87 being mounted on top of the hull (the holes in the hull for the spars were plugged).

Trials with N86 were resumed in October after the new wings had been fitted. On 17 October, Grain Test Report NM 219B was published giving comparisons between N86 and the Felixstowe F.5 prototype, N90, of the view from the pilots' cockpits, layout of instruments, crew accommodation, handling, and take-off and landing performance. With the exception of instrument arrangement and crew accommodation, which were regarded as inferior in the Cork, there was little to choose between the P.5 and F.5. The author of the report might have mentioned (although in fairness to him he was probably not asked to record) that the P.5 was superior to the F.5 under the same operational conditions, in speed, climb and range, and in ability to carry a heavier payload. The report also noted that the P.5 had not yet been tried in rough seas and that the main step had



Cork Mk II N87 inside the hangar at Brough. (*Leslie/Bruce Collection*)

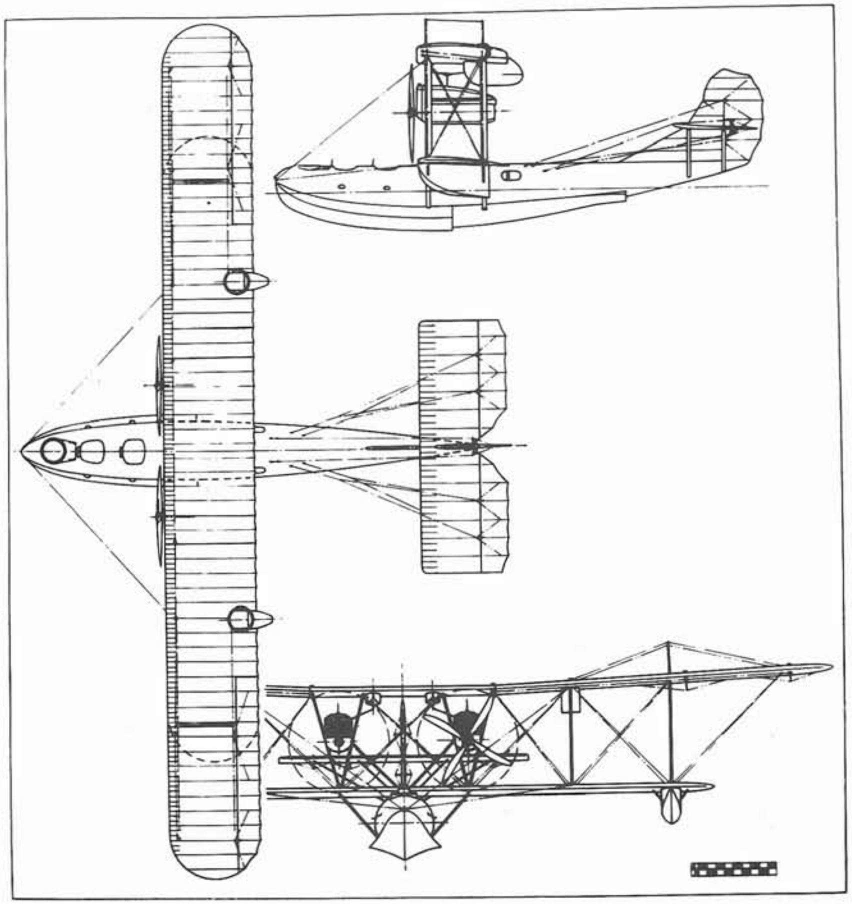
given way once, possibly owing to its being strained on the machine's launching trolley. There followed another report, No. NF2346, dated 22 October, concerning the rudder of N86 and this apparently led to the fitting of one on the lines recommended in NM 219. Overload trials were conducted and reported in NM 240b dated 10 May, 1920. At a later date N86 was fitted with navigation lights.

N86 was thereafter used experimentally at Grain and was known to have been flying as late as April 1924, when it was the subject of impact tests described in R & M No.926.

Construction and assembly of N87, which became known as the Cork Mk II, started about the end of August 1918. On 24 September, Phœnix were notified by the Technical Department of major alterations to be made to the hull. Fortunately by that time only the uncovered lower centre-section and fin had been fitted (whether they had to be dismantled to allow the hull to be modified remains unknown). The alterations were made to Air Board drawing No. D.S.3.034: *P.5 proposed production hull lines*, and were done at Bradford by May, Harden & May's boat-builders between 15 October and 2 November. The hull then resembled that fitted to N86 but had its rear step placed farther aft.

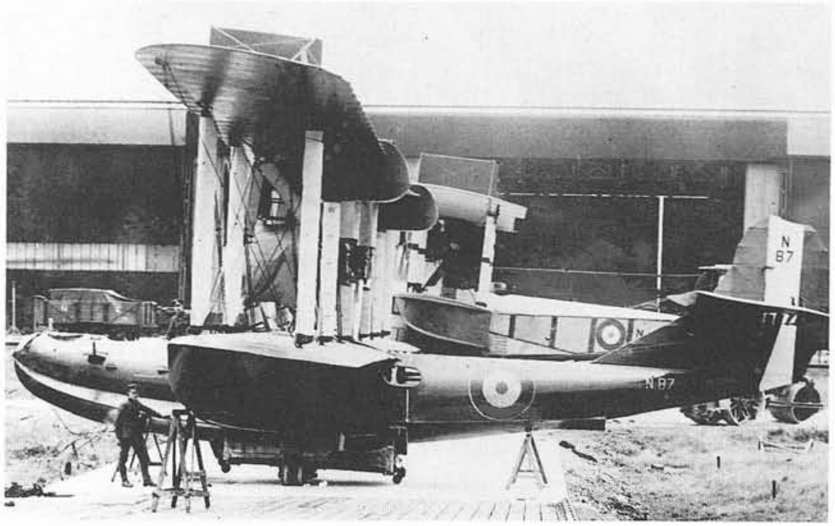
From then, N87's assembly proceeded steadily and by 25 November the uncovered centre-section minus engines and the complete tail unit had been installed. However, further delay occurred when it was discovered that the wings would have to be recovered as the wrong type of dope had been supplied and used to treat them. The Cork Mk II was eventually delivered by road to Brough on 21 February, 1919, for final erection.

N87's first flight took place during the late afternoon of Friday, 28



Phœnix P.5 Cork Mk II.

March, and lasted 7 minutes only, being curtailed because of strong winds. The crew comprised Majors Miley and Wright, pilots, CPO Dryden, Shanate of Rolls-Royce, West of Phœnix and Edwards, engineer. Gales and rough seas foiled attempts, in which a tailplane stay-tube was damaged, to bring N87 ashore and she was left moored to a buoy until the following Sunday evening when it was found that she had not shipped water. The Cork was observed to ride out the gales well and this fact was subsequently widely publicised by Phœnix, who compared N87 to its namesake. Despite the bad weather conditions the test was successful: the take-off was automatic, handling and stability, according to Maj Wright, was perfect, and N87 climbed strongly at 80 mph against a 25 mph head wind. Criticism was made, however, of the petrol pumps and cocks, the former for not delivering fuel at a sufficient rate, and the latter for being dangerously placed between the chain connecting the pump and its windmill. Recommendations were made concerning serviceability, in

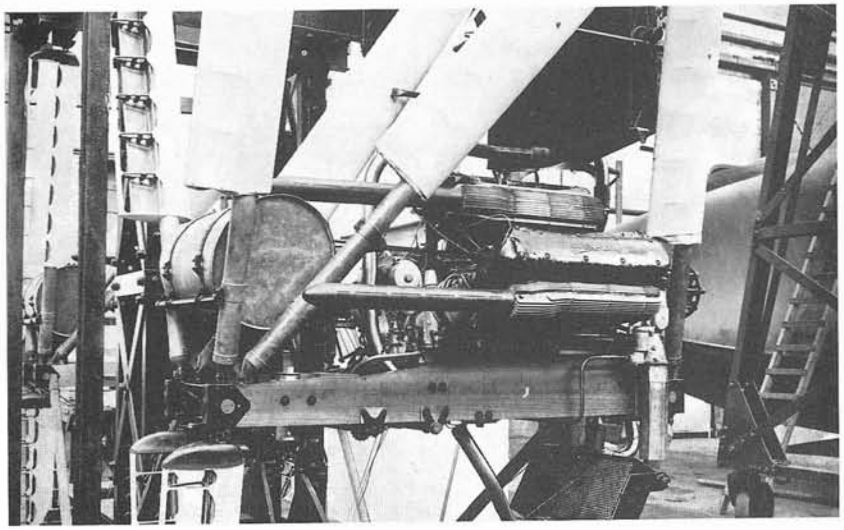


Cork Mk III N87 on the apron at Felixstowe together with the Short Cromarty before their departure with the Flying-Boat Development Flight to the Scilly Isles in August 1922. *(Leslie/Bruce Collection)*

particular, for a towing-eye positioned at the stern for the connection of a rope, to minimise damage to the tailplane stay-tubes by manhandling. Undoubtedly, more test flights were made although these appear to have been interrupted when the wings were recovered yet again, Phœnix receiving a contract, No.PB35A/166/C.66, dated 24 May, 1919, for this work. N87 was flown by Maj Wright to the Isle of Grain in June and from then was used experimentally.

In December 1919 the planing bottom of N87 was badly damaged when the machine was brought ashore on its trolley in rough weather. Repairs were made and completed early in 1920. One result of this accident was the invention of a trolley using inflatable water bags to cushion the hull.

During the summer of 1922 a decision was made to install two 450 hp Napier Lions in N87. A trial erection of the engines, which were uncowled and mounted on a revised arrangement of struts, was made at Bradford. Afterwards, the engines and structure were delivered to the Isle of Grain and fitted to N87, which was then redesignated Cork Mk III. The first flight of N87 with its new engines lasted 10 minutes and was made by Flt Lt G.E. Livock on 2 August, 1922, the day it was to have joined the Flying-Boat Development Flight at the start of its cruise from Grain to the Scilly Isles. N87's flight had been delayed by a faulty petrol system. Flt Lt (later Group-Captain, DFC, AFC, RAF) Livock recalled the occasion saying: 'We had a rather 'do-it-yourself' system, constructed, I think at Grain and not by the makers, and fuel poured into the hull instead of the engines when we turned on the petrol. We had to do quite a bit of pumping out and mopping up before the flight'. N87 joined the Development Flight cruise off Spithead on 4 August.



Part of the Napier Lion engine installation intended for the Cork Mk III. The nose of the hull of the Fairey Atalanta II is just visible in the background. (*via L. G. E. Brown*)

The primary object of the cruise was to gain experience of operating flying-boats away from their home station using a ship as a base. The unit consisted of Short N.3 Cromarty N120, one standard Felixstowe F.5, N4038, one F.5 with Lion engines, N4839, and N87, accompanied by HMS *Ark Royal*, the parent ship, HMS *Tintagel*, a destroyer, and the RAF Floating Dock towed by HMS *St Martin*, a tug. Pilots assigned to the flying-boats were Flt Lt B.C.H. Cross, Flg Off Carey, Flg Off E.P. Davis and Flt Lt G.E. Livock respectively, and the Development Flight was commanded by Sqn Ldr R.B. Maycock. The final report and recommendations of the Flight were given to the Commanding Officer, Marine & Armament Experimental Establishment (Home), Isle of Grain, by Sqn Ldr Maycock on 31 October, 1922. The report began by stating the objects of the cruise in detail and listing the equipment and personnel involved. It continued:

'Summary narrative of the cruise.

Sheerness. The experimental flying boats were handed over to the flight on 13 July, 1922, and, with the assistance of a party of men loaned from M & AEE (H), the programme of work which it was considered essential to carry out to render them fit for the cruise, was completed, as far as possible by 31 July, 1922.

All the flying boats, with the exception of P.5, which was only completed on the day of departure, were tested and found satisfactory before departing.

The *Ark Royal* arrived off Grain on 25 July, 1922, and commenced taking in stores and petrol.

Spithead. With the exception of N.3, which was left behind at the last

moment to change an engine, the Unit sailed for Spithead and assembled there on 4 August, anchoring about 3½ miles SW of Calshot.

The Unit remained here for four days during which refuelling experiments with the *Ark Royal* plant were carried out. This, at first, gave trouble as a considerable quantity of water was found to be present in the petrol tank, the presence whereof has, so far, remained unexplained.

N.3, N120, joined the Unit on 7 August, having had a new Condor engine fitted at Grain.

Portland. The anchorage at Portland was very safe and no amount of wind at this base would have affected the security of the aircraft. It was, however, very congested and considerable judgement was necessary in handling the flying boats when coming up to and leaving the moorings.

A considerable amount of engine trouble was experienced here with the Napier Lions installed in F.5, N4839, and Rolls-Royce Condors in N.3, N120, and minor hull and rigging defects were corrected in all flying boats. It was not possible, therefore, to carry out many concerted tests at this port and, moreover, it was considered by the Officer Commanding Unit that it was only on passage to its main base at Plymouth prior to leaving for the scene of operations and that it was not the intention to carry out trials at this stage. The weather at Portland was alternately good and bad.

Plymouth. The Unit assembled at Plymouth on 14 August, 1922, and anchored in.

A programme of exercises and tests was prepared, but little of this programme was actually carried out owing to a recurrence of engine failures and administrative difficulties arising out of the 'serious differences' reported by the Captain to have arisen between himself and the senior RAF Officer. Up to this period, however, a great deal of useful information and data had been collected on the general scheme of working with a Parent Ship, the maintenance and handling of flying boats as a unit, on the water, moorings, refuelling, and the inestimable value of the Seaplane Dock.

The weather at Plymouth was similar to that experienced at Portland, wet and fine days alternating, and the effect of this was beginning to show up on the flying boats. Rust and corrosion could not be kept under and the planes were becoming groggy.

Scillies. The Unit sailed for and arrived at St Mary's Roads, Scilly Isles, on 21 August, 1922. This anchorage possesses practically no shelter from the SW except for a few rocks, and the Atlantic swell very rarely, at this time of the year, ceases to roll in from that direction and, if accompanied by any wind, the sea becomes dangerous to any craft of small tonnage. In this respect this anchorage proved the most severe test of the seaworthiness of the flying boats of almost any possible to select.

The south westerly swell was so continuous that it was found impossible to use the Seaplane Dock on more than an average of one day in four, owing to its excessive movement and the wash and send of the sea inside when submerged for docking.

On days suitable for air operations, it was, generally speaking, quite calm, and the swell at the anchorage coupled with the fact that there was no wind, made the difficulty of getting the flying boats off into the air one of some hazard, and imposed a great strain on the hulls and superstructure....

[The] Scillies is the most exciting testing place but, when working there, the best anchorage should be selected. This, however, was not done, as, in the first instance, the flying boats were moored out to sea and windward of the Parent Ship and the Destroyer. Later, they were moved to a more sheltered position but not until they had rode out one gale during which it was impossible to get them in and, to illustrate this, it may be mentioned that the ships' boats were hoisted or sent to St Mary's for shelter.

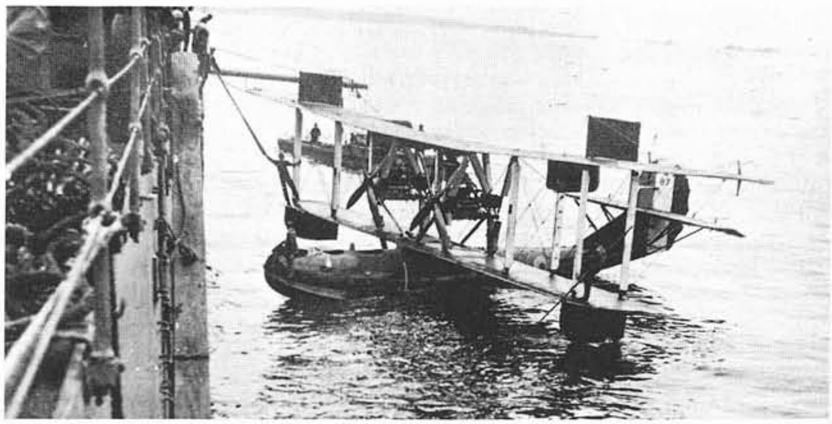
At this base the maintenance of hulls and superstructure absorbed all the energies of the Flight and as it was not always possible to use the Dock, repairs were executed on a sandy beach and the pool off this beach provided the best anchorage for flying boats.

The period spent at the Scilly Isles was the most instructive of the whole cruise from an experimental point of view and, although the numbers of hours flown was negligible compared with what could have been carried out had the flying boats been of a standard type, the experience gained in the proving and establishment of certain definite characteristics of flying boats—both affecting their possibilities and limitations—should prove of assistance in determining their future military value and to designers in evolving a seakeeping aircraft.

[On 31 August, 1922, Flt Lt Livock made an aerial reconnaissance of Falmouth in conjunction with N4038, during which take-off tests were conducted in Mount's Bay and N87 was refuelled from HMS *Tintagel* off Penzance.]

Eighteen days were spent at the Scillies and the weather prevailing was similar to that usually experienced during November. The flying boats had become so saturated and engines so corroded with salt water—due partially to their age, partially to the exposed anchorage and partially to the constant bad weather—that it was deemed advisable as a result of these conditions coupled with the loss of N.3, N120, from the same causes, to move the base back to Portland.

Portland. The Unit sailed for and assembled at Portland on 8 September. N.3, N120, having been lost at the Scillies and N87 having sustained



Cork Mk III N87 drawing alongside HMS *Ark Royal* during the cruise to the Scilly Isles. (*G. E. Livock*)

serious damage to the forward step during the flight to Portland, only the two F.5 types remained effective and with these, two successful air operations were carried out from this base, also some further experimental trials.

On the completion of these operations and trials the Unit was prepared for the return flight to the Home Base at Grain, and, on 18 September, 1922, the Unit sailed.

Grain. The two F.5s reached Grain without incident but P.5, N87, came down at Newhaven, the outer aluminium exhaust manifold on the port engine having fallen off in the air and remained suspended by a wire stay.

The *Ark Royal* arrived at the Nore on 19 September and came up harbour on the following day and, by 09.00 hours next day, all RAF personnel and stores were landed as the vessel was required for service elsewhere.'

The report proceeded to give more detailed accounts of the performance of each flying-boat and the rest of the unit. Comparisons of the types were made and it was concluded that N87 was better than the Cromarty and far superior to either of the F.5s. The conclusion took into consideration each machine's condition at the start of the cruise and that of N87 was rated the worst! Appended to the report were the comments of the pilots on the performance and defects of their machines. Those of Flt Lt Livock read:

General characteristics. No figures were taken for performance except take off which averaged 24 secs in a flat calm with no wind and full load up.

The air speed indicator did not work correctly so it is difficult to gauge the exact full speed which is somewhere in the region of 101–104 mph.... The best cruising speed was about 78 mph, the leading speed [*sic*] being about the same as on F.5.

Control. The controllability in the air is excellent with the exception of the aileron control which appears to be a little insufficient, this is noticeable at very low speeds such as stall landings and take offs.

The rudder and elevator controls are very good.

This type is much more pleasant to fly for long periods than the F.5, and is not nearly so tiring on the pilot.

There is a very pronounced 'snatching' on the elevator controls when engine speeds are varied in the air. This may be due to the tail oscillation [caused by lateral bending of the hull].

Control on water. The machine is very steerable on the water at low speeds, but sea anchors are required for picking up moorings etc, except in very strong winds, as the machine travels very fast through the water, even with the engines throttled right down.

The controllability at high speeds such as when taking off is good and the tendency to porpoise can be controlled to a great extent by the elevator.

The difficulty in taking off is the danger of dipping a wing tip into the water. The wing tip floats being so low, any tendency of the machine to roll laterally has to be quickly checked, otherwise damage to the wing tip can easily result. This makes a cross wind take off especially difficult. When taxying across a cross wind at any speed it is quite easy to entirely submerge a wing tip float and have water running 'green' over the lower plane. Apart from this the machine is very clean when taxying, not making nearly so much fuss as on F.5.

Seaworthiness. The seaworthiness of this machine was well tried out as six gales were ridden out without any damage whatever, and high seas, especially at the Scillies, were frequently experienced. It is interesting to note that one gale of Force 6, lasting nearly 24 hours was ridden out safely without the rear side doors in place. A small amount of water was taken in but not enough to endanger the machine. A certain amount of water, however, is taken in at these doors when taxying side to wind or turning quickly on the water.

Loss of performance. The loss of performance, both in the air and taking off, as well as controllability was very marked towards the end of the cruise, this I consider due to the following causes:-

(1) Hull becoming sodden with water.
(2) Considerable leaking into the outer skin, which could not be kept under by the bilge pump.
(3) Fabric on planes becoming slack. It is pointed out that the fabric was old and practically rotten before the cruise started.
(4) Planes becoming out of truth from various causes.

To sum up it is considered that this type [P.5] with the few small alterations recommended in this report should prove infinitely superior to the present F.5 in almost all respects.'

Group-Capt Livock later recounted the last days of N87. 'The last flight [from Portland on 18 September, 1922] was very unpleasant. I just managed to haul her off the water after taxying for miles. In the air she was horrible on account of the enormous load of water carried in the step compartment. Off Newhaven, I had to force land owing to an exhaust manifold breaking off and directing the exhaust flames on to the magneto. I attempted to take off again after effecting temporary repairs but owing to her poor condition and having regard for the bumps felt from the crests of the waves this seemed inadvisable, so I taxied her into Newhaven harbour and tied up to a mooring in the entrance. That night a gale sprang up, the mooring dragged or parted and N87 crashed into a pier. The machine was then towed up the harbour to a jetty where we secured her. Whilst attempting to dismantle her on the water, she heeled over, filled up and sank. We eventually hauled her out of the water in pieces, which were put on a trailer and taken back to Grain by road.'

Interest in the Cork was shown in many quarters, particularly by the American Aviation Mission in August 1918, and by Boulton & Paul Ltd who received drawings of the hull in December 1919 to study for its conversion to steel and wood construction.

A civil variant of the Cork, designated P.8, was considered by the Phœnix Dynamo Co. It was to carry ten passengers or freight. Manning also investigated the possibility of entering the Cork for the £10,000 prize offered by the *Daily Mail* for the first direct transatlantic flight. His calculations indicate that the Cork could have accomplished the flight with ease.

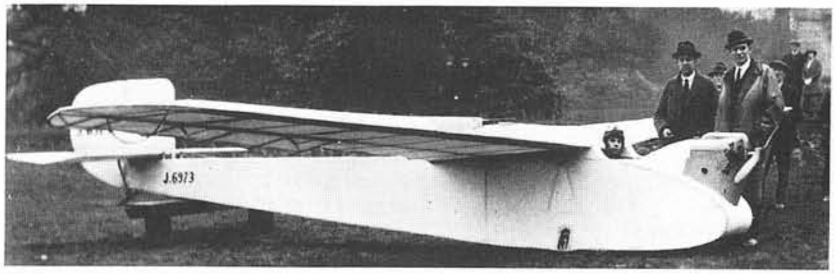
The Cork was later developed as the Napier Lion-powered English Electric P.5 Kingston.

Span: upper 85 ft 6 in, lower 63 ft 6 in; length: Mk I 48 ft $7\frac{3}{16}$ in, Mk II and III 49 ft $1\frac{11}{16}$ in: height: Mk I 20 ft, Mk II and III 21 ft 2 in; length of hull 45 ft; hull width across chines 7 ft 6 in; hull maximum depth 6 ft 2 in; wing chord 9 ft; wing incidence 4°; wing dihedral:

upper 3° (outboard section only), lower 0°; gap at inboard interplane-struts 10 ft; stagger nil; aileron span 19 ft $11\frac{1}{2}$ in; aileron chord 2 ft 1 in; tailplane span 25 ft; tailplane chord including elevator 8 ft $6\frac{1}{2}$ in; tailplane normal incidence 5° 30′; elevator span 25 ft; elevator chord 2 ft 9 in; fin height 6 ft 3 in; fin root chord 10 ft 1 in; rudder height Mk II and III 10 ft $3\frac{5}{8}$ in; rudder chord Mk II and III 4 ft $0\frac{1}{8}$ in; propeller diameter 10 ft; wing area including ailerons: Mk I 1,292 sq ft, Mk II and III 1,340.5 sq ft; total aileron area 85.5 sq ft; tailplane area including elevator 200 sq ft; total elevator area 58 sq ft; fin area 31 sq ft; rudder area: Mk I (9 Aug, 1918) 22.5 sq ft, Mk II and III 42 sq ft; total stabiliser area 34.5 sq ft.

Hull weight: P.5 1,417 lb, P.5A 1,306 lb; empty weight: Mk I 7,350 lb; loaded weight: Mk I 11,600 lb.

Maximum speed: Mk I 105 mph at sea level; climb to 5,000 ft: Mk I 10 min; service ceiling: Mk I 13,000 ft; endurance: Mk I 8 hr.

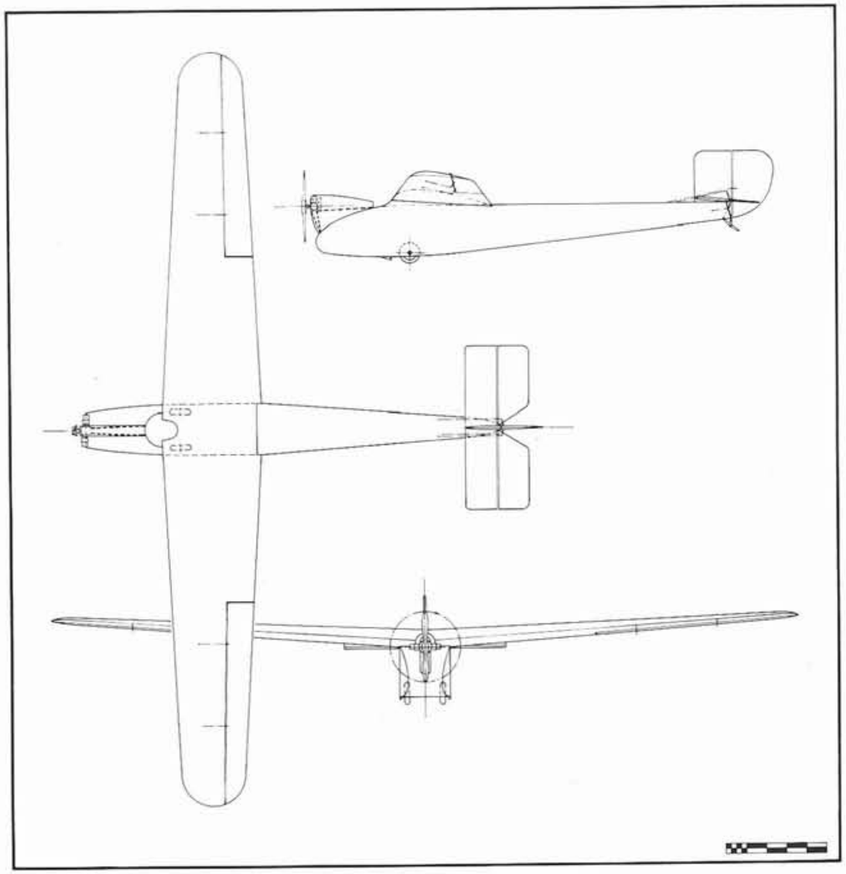


The prototype Wren at Ashton Park, Preston, on 5 April, 1923. In the cockpit is Sqn Ldr Maurice Wright and the taller of the two men standing by the aircraft is W. O. Manning. (*A. Winter*)

English Electric S.1 Wren

The possibilities of flight using minimum power occupied W.O. Manning's thoughts in 1922 as he watched the gliding over Itford on the Sussex Downs. He knew the requirements for a high-performance glider and considered that many of those he saw would benefit from the introduction of features known to reduce drag. Particularly external bracing could be eliminated by the use of cantilevered flight surfaces. If the aerofoil shapes being evolved (deep sections with high lift/drag ratios) could be used efficiently then, he argued, cantilever wings of hitherto unattainable structural stiffness could offer substantial improvements in a glider's performance. An aeroplane with a cantilever wing and an engine of small power output should then provide a financially economical machine with a reasonably good performance. These features Manning combined in a single-seat tractor monoplane.

Design work began in earnest towards the end of October 1922, when Manning evaluated a number of wing forms with respect to their aerodynamic characteristics and weight. After much paperwork he chose an equi-tapered semi-circular tipped wing with an aspect ratio of about nine and a modified RAF 64 aerofoil section. The final choice of powerplant was a 398 cc ABC flat-twin motor-cycle engine, which



English Electric S.1 Monoplane.

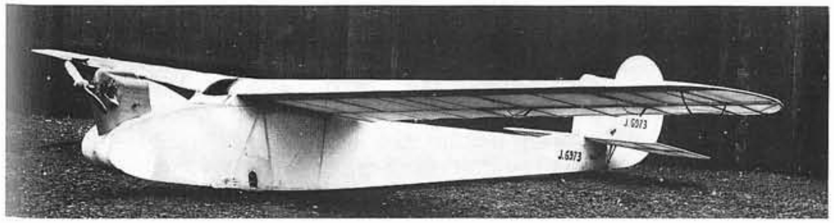
developed a maximum of 7¼ hp at 4,500 rpm and had a normal output of 3 hp at 2,700 rpm. The resultant design was given the designation S.1 Monoplane. It was a high-wing machine with its pilot seated so that his head was cradled in a cut-out in the leading-edge of the wing, which was given 4 degrees dihedral. The wing was covered with special light glider-fabric tautened with Titanine dope, had a wire trailing-edge and two spruce and plywood box-spars braced with wires and compression ribs, which replaced the more usual drag struts. For transport, the wing could be readily detached from the fuselage by unfastening four pairs of U-bolts and wing-nuts, and be separated at the centre-line by removing the bolts and steel fish-plates at the spar ends. The fuselage was a wire-braced box structure of spruce with plywood gussets, which served to anchor the bracing-wires. Plywood was also used to reinforce the nose-section forward of the pilot and to cover the upper leading surface of the wing as far aft as the front spar. The shaping of the nose enabled landings to be made on rough ground without nosing over. At one stage of the design a

separate nose-skid had been considered but later, Manning suggested that the undersurface of the nose fuselage could be used as a broad-faced skid, which itself could act as a brake by holding the nose down with the elevator. The undercarriage was partially buried within the fuselage, primarily to reduce drag although there were beneficial side-effects when landings on rough ground were considered. The wheels were sprung simply by binding their common axle to the bottom longerons with rubber cord. The tail unit was conventional but the rudder and fin had various shapes. As originally designed, the fin was rectangular and the rudder and fin profiles were made continuous. This form was used in the prototype. Shortly after the prototype's initial trials a rudder of increased area was fitted: this was well-rounded and projected above the fin. Finally, the fin was increased in area by increasing the length of its trailing-edge, the top of the fin at this point being on a level with the rudder. The pilot's controls were conventional.

The engine, which drove a small-diameter two-blade propeller made of four laminations of Honduras mahogany, was carried by a tubular-steel structure bolted directly to the top fuselage members, and had a slim aluminium fairing housing the petrol and oil tanks.

On completion of the preliminary design, Manning approached the Air Ministry and offered to build them a prototype for £600. The offer was accepted, contract No. AM/406094/23 awarded to English Electric, and a specification written around the S.1 calling for an ultra-light training aircraft capable of 30 min endurance. With official acceptance came the designation Wren, and the allocation of serial number J6973. Construction of the prototype at English Electric's Dick, Kerr Works, Preston, started on 5 February, 1923, and was completed exactly two months later. That same day, the Wren was taken by road to nearby Ashton Park for trials, during which it was found that the aircraft could take off from the rough surface in about 50 yards with a head-wind of 8 mph. Three take-off and landing runs were made and each time the Wren left the ground quite easily, but no protracted flights were made because of approaching darkness. The tests showed the Wren to be slightly uncontrollable directionally, however. A new rudder of increased area was fitted during the next few days.

Afterwards the modified Wren was taken by road to Lytham, where, on 8 April, it made its first long flight from the sands. Sqn Ldr Maurice Wright, the pilot assigned by the Air Ministry to flight test the Wren, described what took place in a paper he read before the Institution of Aeronautical Engineers, on 11 May, 1923:



The prototype Wren with enlarged rudder, in which form it made its first protracted flight, on 8 April, 1923. (*The English Electric Co Ltd*)

'With a view to carrying out a straight flight from the sands to test the controls the machine was taken out in a 15 mph wind blowing along a narrow strip of sand which was gradually being eaten up by the in-coming tide. When the throttle was opened up gradually nothing much seemed to happen, but the last part of the travel of the throttle lever made the machine sit up and take notice and trundle along the sands. After she had covered about 6 ft she began to accelerate so rapidly that she reached flying speed after covering about 30 yards. [I] kept her on the ground so as to have ample reserve of speed before lifting her clear, and as a result the total run taken in this case was about 50 yards. Once in the air she handled so well and was flying so strongly that it was decided to make a more protracted flight, and she was held at an air speed of just over 40 mph at which speed she was climbing strongly enough to reach a height of 100 ft in quite a short time. The engine was then throttled down and the same air speed maintained, but, nevertheless, she did not stop climbing and reached about 300 ft in approximately 5 minutes of leaving the ground.

'Shortly afterwards a landing was effected in a field by the side of a main road, where the wings were subsequently detached and the aeroplane taken in tow by a car [to its base at Lytham].'

The flight would have been longer but as invariably happens a new aircraft of an entirely new type has its faults and the Wren being no exception, the flight was curtailed. The faults were reported as minor but the flight had shown aileron control to be insensitive owing to a lack of torsional rigidity of the wing. The wing was stiffened by doubling the internal bracing-wires, this modification being made during May.

On 14 June, the Wren made a flight of over one hour's duration with the object of obtaining accurate and reliable figures relating to speed, speed range, climb and manoeuvrability. During the flight, which was made by Sqn Ldr Wright, the Wren climbed to an altitude of 2,350 ft and was found to have a maximum speed of 52 mph. The following morning the Wren was flown for 68 minutes between 200 and 300 ft on ⅞th of a gallon of petrol.

These flights clearly demonstrated the Wren's abilities and as these had fulfilled the designer's expectations, the English Electric Company decided to put the machine into production as an easy to fly and economic aircraft, priced at £350. The company, knowing that the *Daily Mail*-sponsored Light Aeroplane Competition was to take place (at Lympne in Kent) in the not too distant future, decided to enter two Wrens and to use the accompanying publicity to promote sales. Work started on the first of the competition Wrens on 19 June, 1923, and on the second shortly afterwards. The competition Wrens, designated Mk II (the prototype was retrospectively designated Mk I), differed from the prototype by having specially tuned engines, wings set at 2 degrees dihedral and raked forward so that the leading-edge was almost at right-angles to the centre-line, a tailplane of slightly reduced span and a new fin and rudder. In all other aspects the Wrens were identical.

The prototype, meanwhile, had been taken to Hendon where it was to appear in the RAF pageant on 30 June bearing the display number 11. During the following week the Wren was flown by a number of well-known RAF pilots of the period, including Sqn Ldr H.J. Payn and Flt Lt W.H. Longton. Generally, the Wren flew very well (even on an occasion

when the engine had oiled-up) and created a great amount of interest, with the result that it was retained at Hendon for another week before being handed over to the Aeroplane Experimental Establishment at Martlesham Heath for official handling trials.

Trials of the Wren were conducted during August 1923 but were of a preliminary nature only, the inclement weather preventing climbing tests and an assessment of manoeuvrability at altitude. Before the trials began, however, the AEE made some small modifications to the airframe. These were: the replacement and strengthening of the wing attachment U-bolts; the straightening of the fin which was found to have a decided set sufficient to cause the directional trouble found on trials before delivery to the AEE; the fitting of a new type of petrol tank of slightly larger capacity with a fore and aft horizontal tube to take the engine revolution indicator drive, and the strengthening of the tailskid attachment which had fractured on delivery. The trials were summarised in report No.M.348, of 4 September, 1923, which concluded:

'Speed. Full out true speed:- 49 mph.

Controllability. Criticism of the various controls are divided as would be expected with a machine of this type into two parts dealing with the conditions engine 'on' and 'off'. Weather conditions have varied from calm to rain and gusts up to 15–17 mph.

(a) Engine 'on'

Longitudinal. This control is very effective and light at all speeds but the elevator must naturally be pulled back gently otherwise loss of speed is obtained with no climb, the same line of flight being maintained.

Lateral. Ailerons for small movements and banks are light and effective but are slower in operation compared with elevator control. A peculiar effect is felt in banks over about 15° and when correcting large wing 'bumps', the ailerons becoming very stiff in proportion to hold on to. In fact the impression given to pilots is that further pressure would break some part. This is quite possibly due to warping of the main planes near the wing tips.

Directional. The rudder is very light and if anything too effective, being rather out of proportion to all the rest of the controls. This condition, however, cannot be altered as rudder control must be provided for engine 'off'.

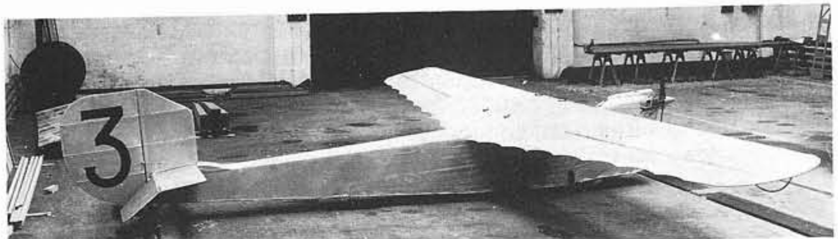
(b) Engine 'off'

Ailerons and rudder are quite effective under pure gliding conditions also the elevators, which are sufficiently powerful and efficient to counteract the 'nose' heaviness which is very definite with engine off. Fore and aft control is maintained right up to the moment of the machine losing flying speed. When this is lost the machine falls suddenly. Landing speed is approximately 25 mph.

General Notes:

1. The machine cannot be pulled off the ground. If this is attempted immediate slowing down occurs. Taking off must be done in the machine's own time, the pilot just balancing the glider on the wheels.

2. If the elevators are pulled up gently the nose comes up till the air speed indicator shows 28 mph. Further elevator has no effect the machine sinking even with full engine.



Competition Wren No.3 in the workshop at Preston. (*The English Electric Co Ltd*)

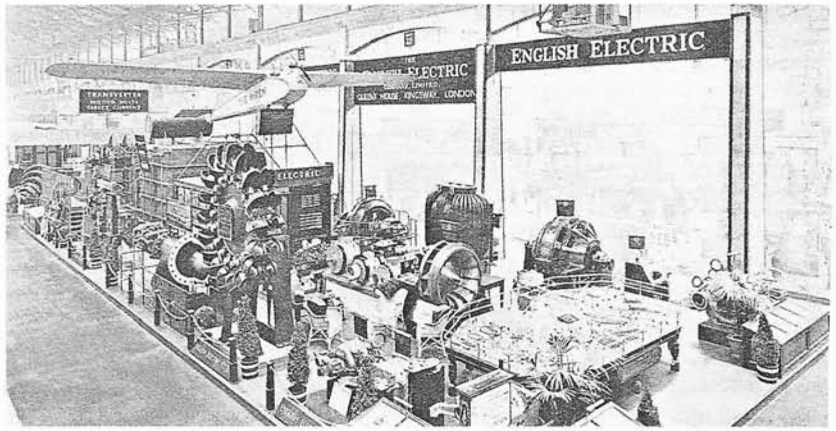
3. The rudder must be treated very gently taking off otherwise swinging will quickly result.
4. All take offs were done from the tarmac aprons as the wheels fitted do not allow taxi-ing over the ordinary AEE aerodrome surface.

A further report after completion of present repairs and fitting of larger wheels will be rendered in due course.'

Further reports have not come to light and the fate of the prototype Wren after this date remains in doubt. The report, however, confirmed the manufacturer's trials' figures and lent credence to the company's claims.

The competition Wrens were now ready and in the first week of October were delivered to Northolt for preliminary trials before the 1923 Light Aeroplane Competition, which opened on 8 October. From Northolt, the Wrens, bearing competition numbers 3 and 4 on their rudders, were taken by road directly to Lympne, but the journey was not without incident. On the way a horse shied at the unusual sight and hit Wren No. 3 with part of its bridle causing damage which took a few hours to put right. The repairs were put in hand as soon as the aircraft arrived at Lympne. During Sunday, 7 October, it was decided to draw lots for the orders of starting in the competition: Flt Lt Longton who was to fly Wren No. 4 drew first place and shortly after 8 o'clock the following morning took off, quickly followed by the other competitors. Sqn Ldr Wright flew Wren No. 3. Longton went up again in the afternoon to improve on his fuel consumption figure, which he did with 85.9 miles/gal but A.H. James flying an ANEC monoplane had established a figure of 87.5 miles/gal. However, James's figure was equalled by Longton with a flight on 18 October and as this remained unbeaten throughout the competition, James and Longton shared the £1,000 prize given by the *Daily Mail* and the £500 awarded by the Duke of Sutherland. On the evening of 18 October, Longton crowned his success by giving a brilliantly performed exhibition of stunt flying. After the competition, both Wrens returned to Preston for further trials.

On their return to Preston, however, the Wrens were little used, and in 1924 Wren No. 3 was stored by being suspended from the roof of the Lytham flight shed. Wren No. 4 became the centre-piece of the English Electric Company's stand at the British Empire Exhibition, held at Wembley between 23 April and 1 November, 1924, thereafter being displayed at the Science Museum in South Kensington, London. *The English Electric Journal* of the time described the exhibition Wren as a 'duplicate of the machine which achieved such remarkable success in the

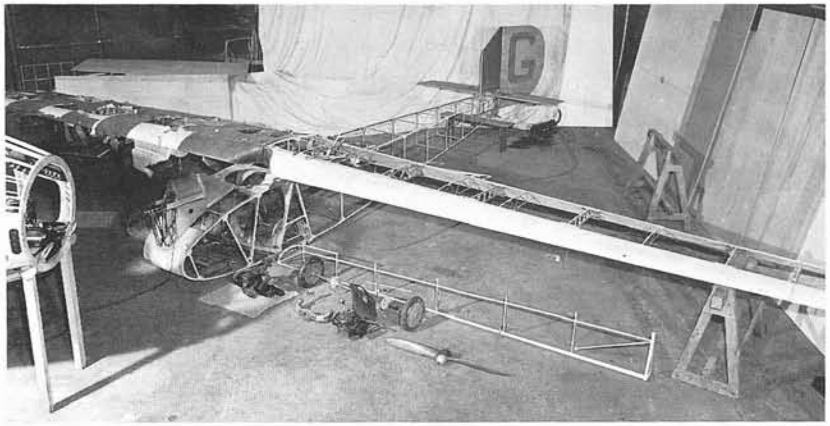


The 'duplicate' Wren on show at the British Empire Exhibition. (*The English Electric Co Ltd*)

trials at Lympne.' Whether or not a fourth Wren was built expressly for the Exhibition remains unknown but there exists a strong possibility that two Wrens marked No. 4 were made and that the original found its way to the Science Museum, where it remained on display until the end of 1945.

Wren No. 3 was retained at Lytham until the closure of English Electric's Aircraft Department in April 1926, when it appeared on the civil register as G-EBNV through its purchase by Alan Smith of Sherburn-in-Elmet, Yorkshire. In 1929, it was withdrawn from service and was stored for a short time at Bradford before its sale to R.H. Grant and subsequent removal to a farm in Dumfries, its earliest existence there being recorded in 1936. Grant had intended to restore the Wren to flying condition and had overhauled the engine with this in mind. In 1944, he wrote to W.O. Manning asking for assistance in the work of reconstruction but the exigences of war made this impossible to give and presumably the idea was shelved.

Also, about that time restoration work was planned for the Wren at the Science Museum and on 4 February, 1946, Wren No. 4 was returned to English Electric's Preston works but restoration was not begun immediately. The Wren was stored in a corridor outside the English Electric Company's offices in Corporation Street, Preston, but its fabric covering was continually being damaged by curious employees. George Chadwick, later to become chief welding development engineer, was asked to take charge of the airframe before it was further harmed and he had it taken to Samlesbury aerodrome, where it was stored in one of the hangars. The Wren remained there for about two months, after which Chadwick was asked to remove it to provide much needed hangar space. Chadwick, subsequently stored the Wren in his own garage in Winfield Lane, Ashton, where it remained for six months before being moved to Warton. In 1954, following a request made by the Shuttleworth Trust, arrangements were made to rebuild and restore the Wren to an airworthy condition. Wren No. 3 had by this time been relocated but was found to be beyond repair. However, some of its engine parts were to prove useful in making its twin airworthy.



Wren No.3 in dilapidated condition and beyond restoration. Some of its parts, however, were used in the reconstruction of Wren No.4. (*The English Electric Co Ltd*)

Peter Hillwood, one of the company's senior experimental test pilots, and a light aeroplane enthusiast, supervised the rebuilding of the Wren, with the advice and assistance of Manning. With the company's facilities to hand and the encouragement of the Shuttleworth Trust, Hillwood and his assistants set about their task by first making a detailed inspection of the two airframes. Despite its age, the timber of Wren No. 4 was found to be in remarkably good condition although many repairs would be necessary: most gussets needed replacing and also the bracing wires and metal fittings which had badly corroded.

No working drawings were available, other than a three-view general arrangement drawing accompanying an article by E.J. Riding published in *Aeromodeller* in January 1946, and so drawings were prepared using the aircraft itself. Meanwhile, all the engine parts were checked, and from the best of these, one complete engine was built together with an engine test rig. Initial runs were made using a flywheel. The engine was stripped and run several times until finally one with high-compression pistons was ready to be installed in the airframe. Two original propellers were in existence but both, unfortunately, were damaged beyond repair. A new propeller was made and further engine runs were made using both Claudel Hobson and Amal scent-spray types of carburettor. The maximum engine speed achieved during the ground tests was 2,400 rpm. A gudgeon pin broke during the final ground run, severely damaging a piston and badly scoring the cylinder. The remaining available pistons were of the low-compression type, but they were fitted and the maximum engine speed recorded at 2,200 rpm. It was decided to try to fly with this engine. The first attempt was made in July 1955 but lack of power made it impossible to become airborne.

The engine was dismantled and the cylinders were rebored. At the same time the opportunity was taken to obtain new pistons. One of the high-compression pistons was sent as a pattern to Wellworthy Ltd, of Lymington, Hampshire, and a new set of pistons was delivered at the end of May 1956.

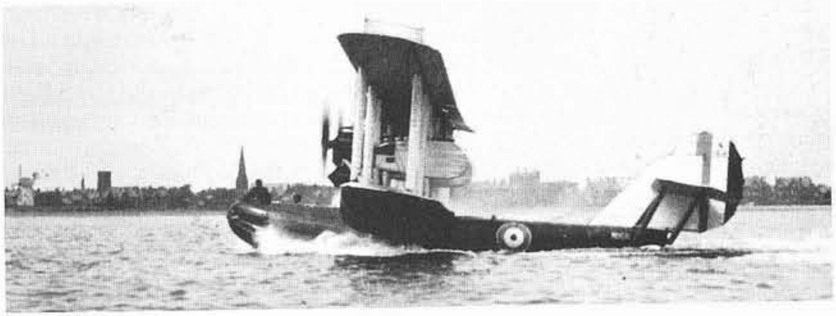
Restored Wren No.4 with Peter Hillwood at the controls. (*The English Electric Co Ltd*)

	S.1 Monoplane	Wren Mk I (Prototype)	Wren Mk II
Reference	EE Drawing No. L.1286	AEE Report No.M.348	–
Span	37 ft 0 in	37 ft 1 in	37 ft 0 in
Length	24 ft 3 in	24 ft 4¾ in	24 ft 3 in
Height at rudder tail down	4 ft 1 in	4 ft 9½ in	4 ft 9 in
Wing root chord	5 ft 0 in	–	5 ft 0 in
Wingtip chord	3 ft 0 in	–	3 ft 0 in
Tailplane span	8 ft 0 in	–	7 ft 6 in
Tailplane chord including elevator	3 ft 1⅞ in	–	3 ft 0 in
Dihedral	4° 0′	3° 15′	2 ft 0 in
Wing incidence	4° 0′	4° 0′	4 ft 0 in
Tailplane incidence	5° 0′	7° 20′	–
Propeller diameter	3 ft 6 in	3 ft 6 in	3 ft 6 in
Propeller pitch	–	2 ft 0 in	–
Wing area including ailerons	146 sq ft	145 sq ft	145 sq ft
Aileron area	23 sq ft	21 sq ft	–
Tailplane area including elevator	23.5 sq ft	22.9 sq ft	–
Elevator area	11.2 sq ft	10.6 sq ft	–
Fin area	4.75 sq ft	4.3 sq ft	–
Rudder area	5.5 sq ft	10 sq ft	–
Tare weight	–	253 lb	232 lb
All-up weight	374 lb	402 lb	420 lb
Maximum speed	–	49 mph	52 mph
Stalling speed	–	–	24 mph
Initial rate of climb	–	–	180 ft/min
Endurance	–	–	1½ hr
Price	–	£600	£350

On 25 September, 1956, the reconstructed Wren flew for the first time, with Peter Hillwood at the controls. Several more flights were made within a short period but altitudes greater than 250 ft were not achieved mainly because of a lack of power. A new propeller of coarser pitch and slightly larger diameter was made, and on the first flight with this fitted, a height of 1,200 ft was reached. This flight also showed that it was possible to reduce power and maintain a speed of just over 50 mph. Later, a large number of flights were made by other pilots, and the aircraft was publicly demonstrated at a number of flying displays throughout 1957.

On 15 September, 1957, the Wren was handed over to the Shuttleworth Trust by the English Electric Company in the presence of W.O. Manning. The presentation was made at the Royal Aeronautical Society's garden party held at Wisley Aerodrome, Surrey.

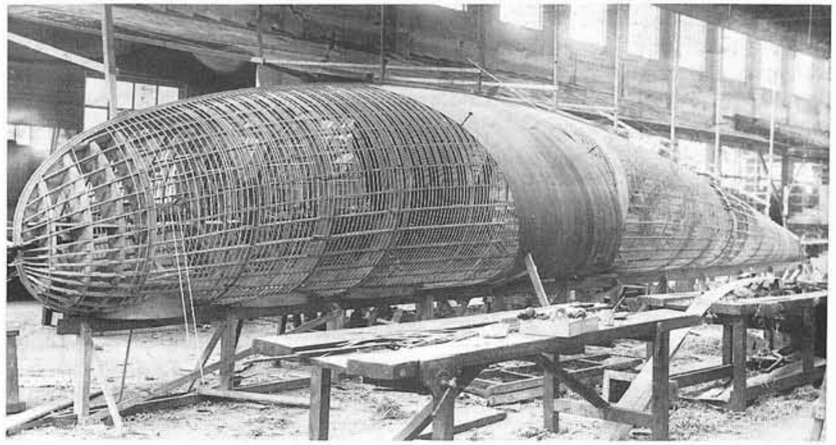
The Wren has been kept in flying trim by the Trust and may be seen today (1986) at air displays held at the Trust's aerodrome at Old Warden, Bedfordshire. Early in 1969, the Wren became number 11 on the register of the British Aircraft Preservation Council, a federation of all groups of enthusiasts concerned with aircraft preservation in the British Isles.



The prototype Kingston, N168, taxi-ing off Lytham during preliminary handling trials before its accident at take-off on 22 May, 1924. (*The English Electric Co Ltd*)

English Electric P.5 Kingston

Preliminary design work for the Kingston was done by a team of six men, led by W.O. Manning, at English Electric's head office, London, in 1922. Working to the requirements, issued in August 1922 and embodied in specification No.23/23, for a coastal patrol and anti-submarine flying-boat, they evolved a design which was based on the Phœnix Cork Mk III. The result of their efforts was a flying-boat similar in layout to the Cork but incorporating the latest developments in hull design, redesigned engine mountings, and a more elegant fin and rudder of larger area. Instructions to proceed with the construction of one prototype were given by the Air Ministry on 20 January, 1923, with the award of contract No. AM/333124/22. Soon afterwards, the initial schemes were handed over for detailing to the drawing office at English Electric's Dick, Kerr Works,



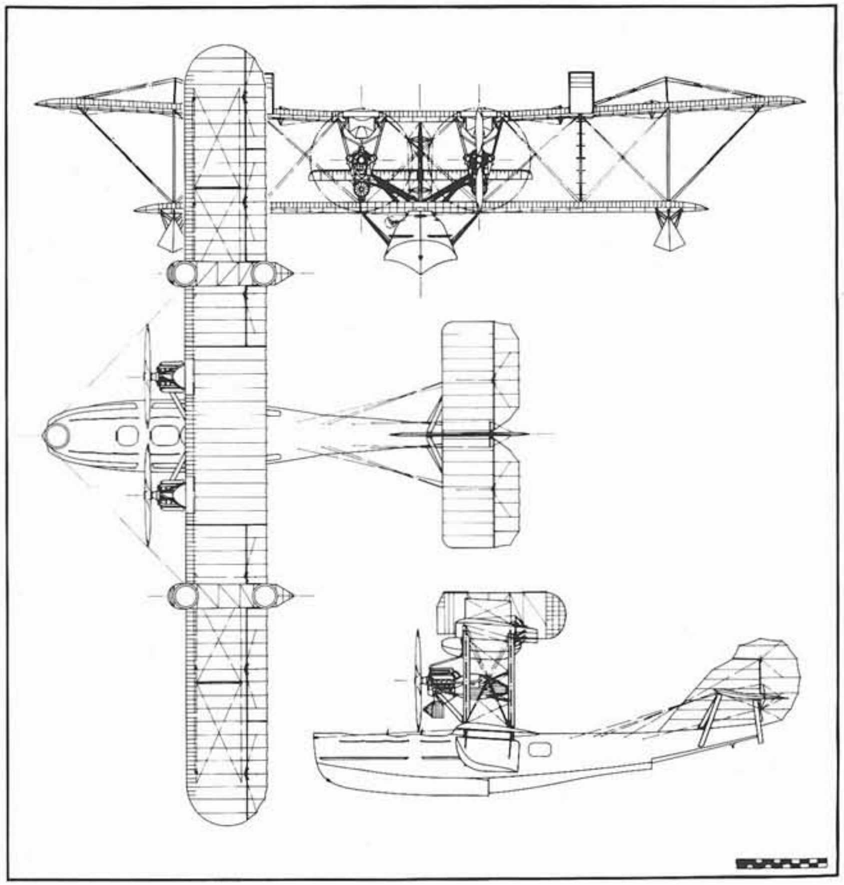
The Linton Hope hull of the prototype Kingston under construction at the Dick, Kerr Works. Timbers have still to be added to the bows and planking amidships has just begun. (*The English Electric Co Ltd*)

Preston. There, work began immediately on the construction of the hull, which was built under the supervision of John Alexander, by boatbuilders specially recruited from the Scottish shipyards along the Forth and Clyde. By the summer of 1923 the hull and most of the superstructure had been completed and a little later the finished flying-boat was taken by road to the flight shed at Lytham for final erection.

On 12 May, 1924, the Kingston prototype, N168, was inspected byAir Ministry officials and on the afternoon of Thursday, 22 May, N168's engines were warmed-up for its first flight. Piloted by Maj H.G. Brackley (then Air Superintendent of Imperial Airways) and a crew comprising C.J. Blackburn, observer, and W.A. Bannister, engineer, N168 was launched without incident onto the Ribble Estuary from the slipway adjoining the Lytham flight sheds. Taxi-ing trials ensued for some twenty minutes after which the flying-boat was brought back to the slipway. Maj Brackley signalled that all was in order and turned seaward into a southwesterly wind and a slightly choppy sea, at the same time applying full throttle. On the point of take-off, N168 stopped suddenly near the estuary training wall amidst a cloud of spray. Shortly afterwards the Kingston began to sink by the nose, and in the space of four or five minutes had pitched forward, until its tail was vertical and its wings rested on the surface of the water, throwing Maj Brackley and Blackburn into the water. Bannister was washed aft inside the hull with the inrush of water through the cockpits. Minutes later the pilot and observer were rescued by the motor-boat *Gnat* of Preston, and the engineer, by the company motor-boat, from the wing kingpost, to which he was clinging having extricated himself somehow from the hull. Surprisingly, the crew suffered no injury. During the rescue operations N168 had drifted downstream but later was secured by the Preston Corporation tug *Aid*. The Kingston was eventually beached at Lytham on the St Annes side of Lytham Pier: the crew having been landed at 2.20 pm. As soon as the tide had left the flying-boat, a party of workmen

set about patching the hull with a canvas shroud and pumping out the water from inside the hull. On Thursday evening, the Kingston was refloated with the help of a tug, but the water proved to be too rough and the current too strong, for both tug and aircraft were swept in towards Lytham Pier. The flying-boat struck the pier and with the tug now in tow, continued drifting upstream. N168 was beached for a second time on the foreshore opposite the Preston Corporation pilots' house-boat, where the canvas patch was renewed and the engines dismantled. On the Friday evening the Kingston was towed back to the slipway. At low tide the aircraft's superstructure was removed and, on the following high tide, the parts were floated up the slipway. Later, the hull was brought up in a similar manner to a point where it could be hauled to the hangar.

Inspection of the hull revealed damage at three distinct points: a small indentation at the bow, and severe damage over the rear of the forward planing surface, and centre of the rear planing surface. Generally, the



English Electric P.5 Kingston Mk III.

planing surface had an abrased appearance. The investigation which followed concluded that the cause of the accident was due to the flying-boat striking flotsam and that the damage resulted from the flotsam bouncing its way aft along the hull bottom. The abrasions were attributed to man-handling over beach and slipway. These findings laid to rest the speculation prevalent amongst the eye-witnesses to the accident that the Kingston had actually struck the stone training wall, which lined the navigable channel of the estuary and was normally covered at high tide.

The accident to N168 did not deter the Air Ministry from placing a further order, for there followed contract No. AM/449553/23 for four machines. Designated Kingston Mk I, the aircraft had serial numbers N9709 to N9712. Of these, N9709 was delivered by rail to MAEE, Felixstowe, N9710 and N9711 were flown to Calshot and N9712 was eventually delivered to RAE, Farnborough.

Production of the hulls for the Kingston Mk Is was undertaken simultaneously at the Lytham flight shed, the superstructure being made ready at Preston. The début of the first of the new flying-boats, N9709, at Lytham, in the autumn of 1924, revealed no startling changes, the only visible differences between it and the prototype being a hull of slightly larger beam, access ports in the hull aft of the lower wing and two-blade propellers. In all aspects of construction the prototype and the Mk I were identical, yet their external resemblance to the Cork was very much apparent. In fact, the Kingston had been designed using photostat drawings of the Cork but the opportunity was taken to make structural improvements. The Kingston's hull had the same overall dimensions as that of the Cork and retained the Linton Hope-type construction, but was revised by the fitting of a continuous rear planing surface and by flaring the fin deck from the chine to the main hull. The latter revision had been tested earlier on models of the Cork hull and showed a small saving in drag. However, the report of the tests, R & M No.461: *The air resistance of flying-boat hulls*, considered the saving insignificant and the idea was not developed at the time. The attachment of the planing surface to the main hull did not follow usual practice, the forward surface being cantilevered from the hull and sprung by means of circular wooden hoops. The rear planing surface, also, was sprung in a similar manner. This method of attachment was thought to minimise alighting shocks to the hull but in practice contributed to unexpected behaviour of the flying-boat on take-off and alighting. Internal layout of the hull and crew positions were similar to the Cork. Flight surfaces differed only by the adoption of an RAF 64 aerofoil section for the wings and a tailplane of slightly smaller span. Instead of the Cork's rectangular-section wingtip floats, new ones, of rhomboidal cross-section, were designed for better seaworthiness. Provision was made for an in-flight, hydraulic tail-trimming gear, patented by W.O. Manning in 1922, but it was not fitted to N168 and N9709.

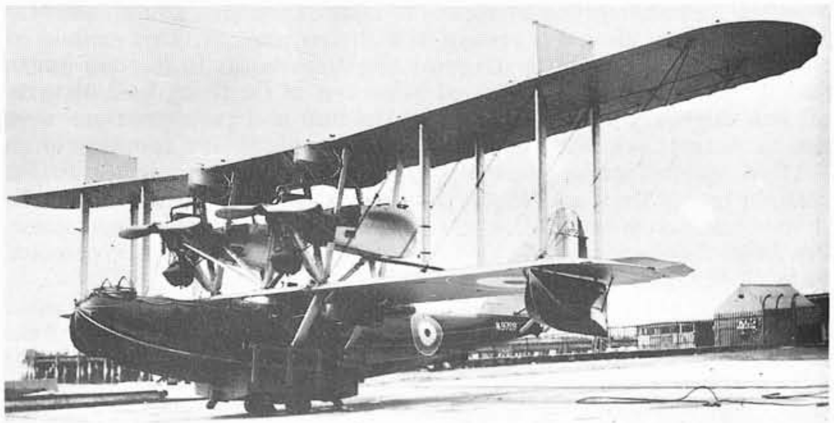
The fitting of two 450 hp Napier Lion IIb engines almost certainly owed something to a similar installation made on the Cork Mk III, although the radiator differed in that it was an RAE conical venetian-blind type made by Serck. Petrol was gravity fed to the engines from two 200 Imp gal tanks slung from the upper wing. A measure of 'fail-safe' was introduced into the petrol system by which either tank or both tanks could be connected to each engine in the event of an engine failure or fuel leak. Water for cooling

the engines was stored in the wing leading-edge above the petrol tanks, and oil in the nacelle aft of each engine.

Three gun positions were provided, each mounting a single Lewis gun with five drums of ammunition; one in the nose and the others at the rear of each engine nacelle. The nacelle gun positions, however, were regarded unfavourably by service crews and were criticised for their impracticability and inaccessibility during flight, even though they offered a reasonable field of fire. It would appear also, that little thought was given to the comfort of the nacelle gunner, who was subjected to propeller slipstream, exhaust fumes and a potential fire risk from the placing of the exhaust pipes close to the fabric-covered nacelle. The exhaust fumes problem was alleviated to some extent by the re-routing of the central exhaust pipe along the starboard side of each nacelle on all aircraft subsequent to the prototype. Two 520 lb bombs carried either side of the hull below the lower wing centre-section completed the Kingston's armament.

Two features introduced with the Kingston were a dinghy carried on the hull abaft the lower wing and a Bristol gas starter, for priming the Lion engines, mounted between the spars of the lower wing centre-section. The dinghy was of Linton Hope-construction and with its oars weighed 80 lb. On acceptance trials of the Kingston, however, these features were considered useful but unnecessary and prejudicial to weight. Despite the criticism provision was made for these items on subsequent marks. Another feature, worthy of note, was the series of electrodes placed along the bottom of the inner hull and wired to lights at the engineer's station. Resembling a spark-plug, the electrodes were to indicate a build-up of water in the bilges, the water completing the electrical circuit on bridging the points of the electrode.

On arrival at Felixstowe, in November 1924, N9709 was re-erected and put through its acceptance trials, the majority of which were flown by Flg Off H.G. Sawyer. The Kingston was found pleasant to fly and stable, but slightly heavy on aileron control. The aircraft was considered to meet type requirements and air-handling qualities. However, the aircraft fell short of

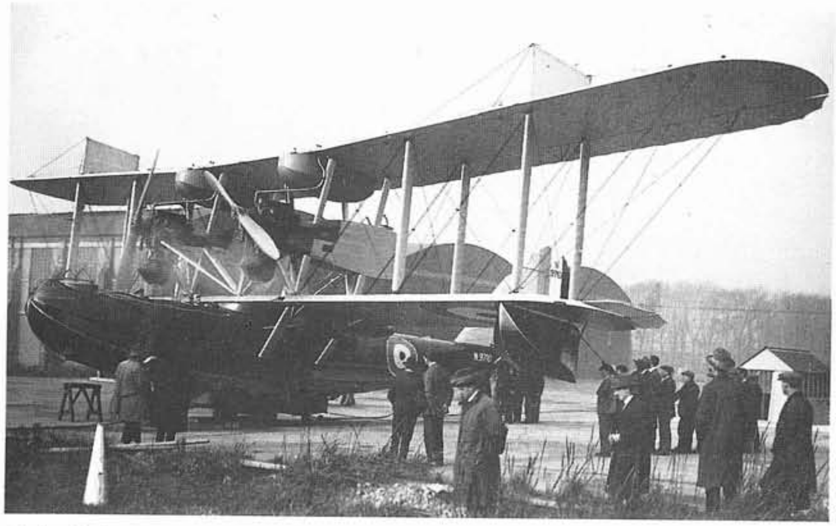


Kingston Mk I N9709 at Felixstowe in November 1924. (*via RAE Farnborough*)

Service requirements with regard to its seaworthiness which was of a low order for its type. Particularly, the flying boat did not behave in a normal manner during take-off, when there was a marked tendency for it to leave the water and fall back again before it could be finally held clear of the water. When alighting the same characteristic was again shown, the hull leaving the water after a good alighting had been made before finally settling. During these bounces the true air speed was higher than that at which the aircraft could be flown when clear of the water, showing that the aircraft had not stalled on the bounce. It was thought that the bouncing was caused by the form of the hull and possibly by the method of springing the planing bottom. With regard to seaworthiness also the hull took in an excessive amount of water through the cockpits when taxi-ing and taking-off, probably due to the dimensions of the hull being too small for the weight it had to carry, and to insufficient buoyancy of the hull forebody. Other criticisms of the Kingston were that the lower wing was too close to the water to ensure the aircraft immunity from damage when moored out in moderate seas and, that the wingtip floats should be modified to prevent water from being thrown upwards over the lower wing.

In an attempt to improve the overall performance of N9709 various alterations were made to the basic airframe. The modifications included the fitting of four-blade propellers and the removal of the engine nacelles and/or the petrol tanks. The fitting of four-blade propellers proved to be a retrograde step. The effect on performance of the removal of engine nacelles and petrol tanks was not conclusive since during the trials, N9709's performance gradually deteriorated for unaccountable reasons, culminating in an accident on 25 May, 1925.

On that day, immediately after becoming airborne, the engines pulled from their mountings and the wing structure failed. The upper wing came



A cloud of exhaust rises from the gas starter engine as it primes the Napier Lion engines of the third English Electric Kingston, N9710, before its first flight at Lytham on 13 November, 1924. The pilot on that occasion was Maj H. G. Brackley. (*The English Electric Co Ltd*)

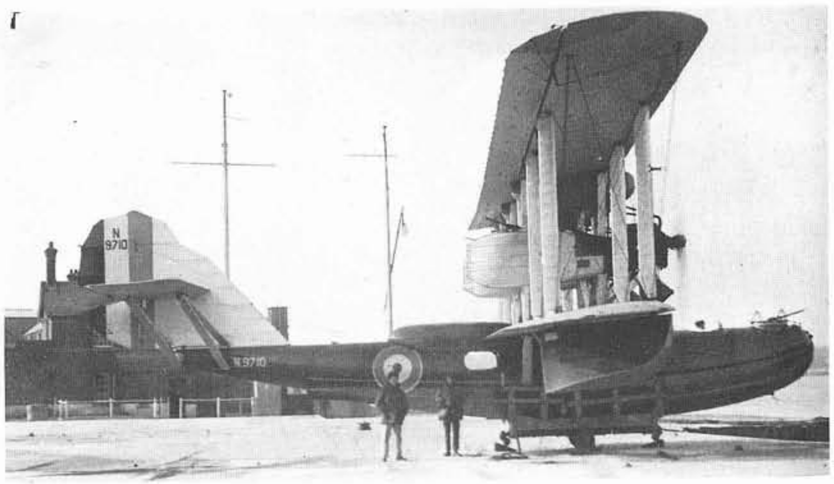
down in an almost perpendicular attitude and its leading edge struck the hull just aft of the first pilot's cockpit. The hull cracked in two places: in a straight transverse line just forward of where the wing struck the hull-top, and horizontally just above the waist line. As the aircraft floated, the weight of the engines and damaged wing was sufficient to bend the hull and open up the crack at the waist line to show water. The occupants, Flt Lt (later Air Vice-Marshal) D.V. Carnegie and G.S. Baker, Superintendent of the Froude Tank at the NPL, escaped from the accident with slight injuries.

The peculiar take-off and alighting behaviour of the Kingston had led to the commissioning of a film of the trials. Filming started shortly after the first flight and was conducted from a launch running close alongside N9709. Ironically, on the day of the accident, the operator, intent on filming and trying to counteract the pitching of the launch, forgot to start his camera!

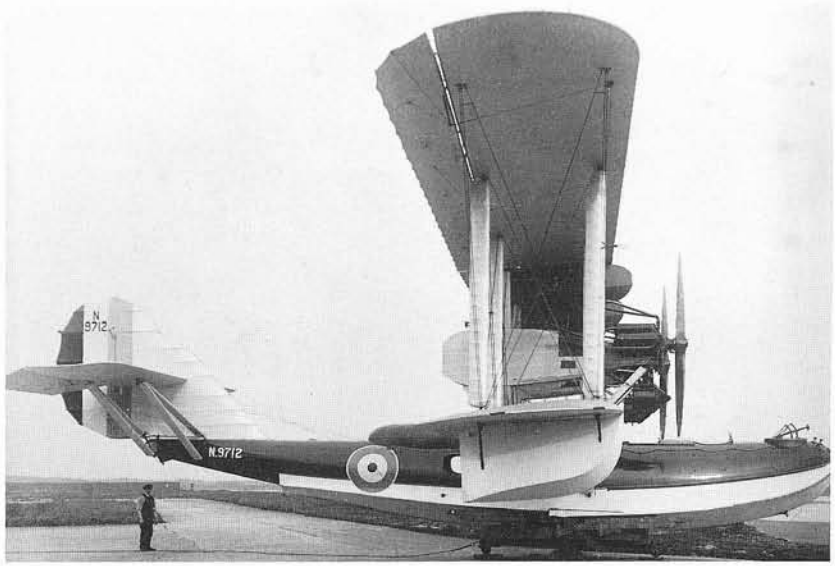
In mid-September 1924, Maj Brackley was notified that the second and third Kingston Mk Is were ready for testing. On 13 November, 1924, he flight tested N9710; his report giving a take-off time of 25 sec and a speed of 109 mph for an all-up weight of 14,200 lb. N9710 was subsequently flight-tested by Marcus Manton, who had become the English Electric Company's test pilot. N9711 was also tested at Lytham and on 19 December was flown to the RAF Base, Calshot, on Southampton Water for Service acceptance trials, but was forced to alight en route at Milford Haven owing to thick fog. It was joined at Calshot by N9710 sometime after February 1925, both being there in the following June.

The last Kingston Mk I, bearing the serial N9712, appeared at Lytham in February 1925. Shortly after its appearance, N9712 was test flown by Marcus Manton.

Before N9709's accident, the Seaplane Panel of the Aeronautical



Kingston Mk I N9710 in June 1925 at Calshot where the type underwent Service acceptance trials. The 'blister' on the top of the hull is a dinghy, which was a standard piece of equipment for all Kingstons. *(via R. C. Bowyer)*



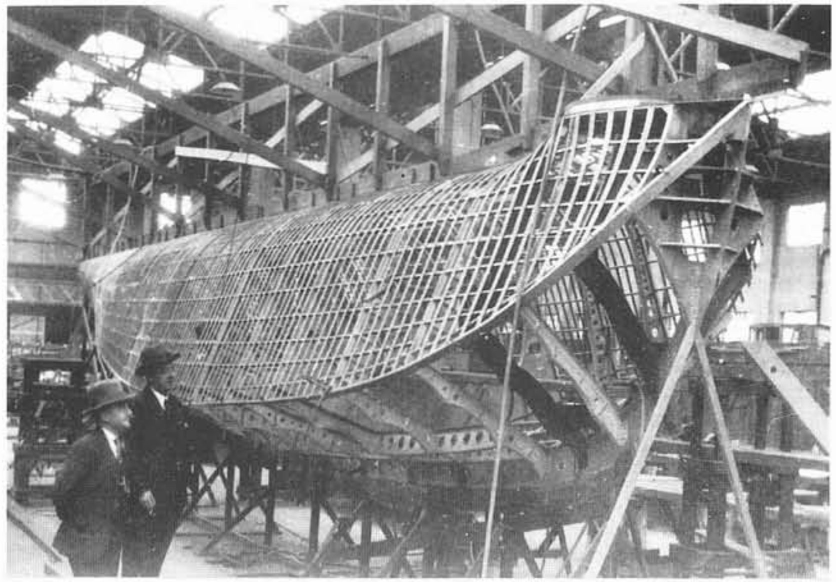
The last of the Kingston Mk Is, N9712, on the apron at Lytham early in 1925.

Research Committee recommended in its report T.2046, dated April 1925, that: 'Arrangements be made for the Superintendent of the Tank (G.S. Baker) to visit Felixstowe to inspect a "Kingston" hull and for a crushing test at the Royal Aircraft Establishment on the sister hull, now at Lytham, on the lines of recommendations to be made by the Superintendent of the Tank'. That G.S. Baker visited Felixstowe on 25 May has been recorded. The crushing test was to supplement similar tests already made on the hull of a Supermarine Seagull. The proposals for a crushing test, however, were partially forestalled by the accident to N9709, G.S. Baker considering in his report to the ARC that 'the accident was a fairly good test in itself'. A further report issued by the Seaplane Sub-Committee of the ARC, (report No. T.2094, of July 1925), stated 'The Sub-Committee have had in a second note from the NPL some suggestions for breaking tests on a Kingston hull, and have decided that the general problem of stresses as associated with design of seaplane hulls should be gone into. The Sub-Committee hope at a later date to put forward concrete proposals from the NPL and the Felixstowe Experimental Station on this subject when the matter has received consideration. In the meantime, it is recommended that the Kingston hull, which is new, should be reserved, and no experiments commenced on it.' The only new hull at Lytham at this time and which was similar to that of N9709, was fitted to N9712 but it had been flight tested. Nevertheless, N9712 was dismantled and despatched to Farnborough early in 1926. Whether or not the superstructure accompanied the hull remains undetermined. In the event, the crushing test was not made, the hull being stored by mooring it nearby on the Basingstoke Canal, the hull's earliest existence there being noted in 1931. At the outbreak of war in 1939, the hull was towed to Greatbottom Flash,

Kingston Mk II N9712 photographed at Lytham in March 1925. (*The English Electric Co Ltd*)

Ash Vale, near Farnborough, where it was moored on Air Ministry instructions, issued under the Defence of the Realm Act, as an obstruction to enemy seaplane landings. Over the years the hull has been the object of adult and juvenile mutilation, as well as the ravages of time and weather. In May 1970, all that had remained (a small piece of the planing surface and keel) was salvaged by officer cadets from RAF Henlow for exhibition at the RAF Museum, Hendon.

In March 1925, the Kingston Mk II, also bearing the serial N9712, was shown for the first time at Lytham. This flying-boat had a metal hull of entirely revised form but the superstructure was identical to its predecessors. The hull, built to Air Ministry contract AM/433950/23, was made of duralumin sheet with stainless-steel for the highly stressed members, which transmitted the loads from, and formed the attachments for the wing-root stay tubes, bracing wires and tail unit. The lines of the hull differed considerably from those of the wooden hull in that the sides were flat and sloped from the chines to the curved hull top which they joined tangentially. This feature not only did away with reflexed curves in the plating but, it was believed, made for cleaner running. The hull section also made for simpler hull-frame construction. The planing bottom was V-shaped, but instead of the usual plain surfaces there were six concave flutes (three on each side of the keel), which ran approximately parallel fore and aft. The fluted planing bottom was intended to make for cleaner running, and was, in addition, particularly suited to metal construction, as the curved plating added stiffness to the bottom which could not be otherwise achieved except by increasing the number of hull frames and increasing the plate thickness at a prohibitive weight. Short Bros had first adopted the fluted planing surface in the design of the Singapore and had patented it. The English Electric Company had, by copying the principle, directly infringed Short's patent but lack of funds had precluded Shorts from taking action. The hull was painted externally with Rylard pearl-grey enamel, apart from one plate, near the main step on the starboard side, which was anodically treated for an experiment by the RAE. In fact, little was learnt about the corrosion resistance of anodised duralumin as the plate was painted in error and the paint scraped off damaging the anodic



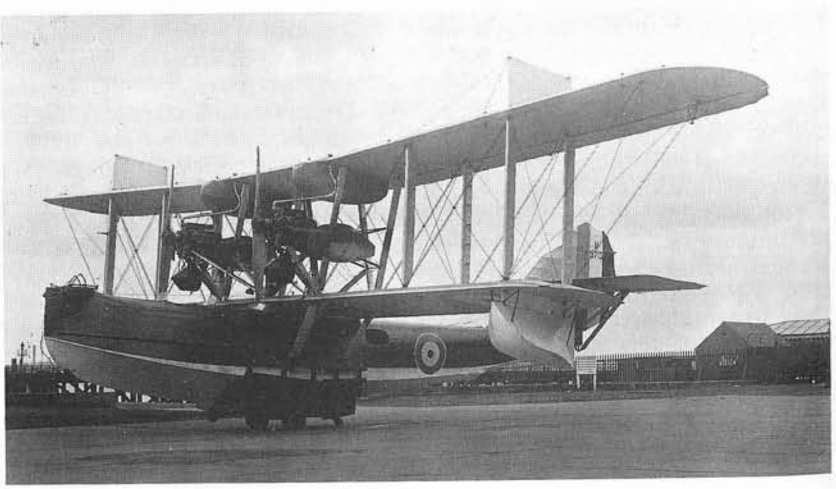
The metal hull of the Kingston Mk II under construction at Preston. Note the similarity in its construction to that of the Linton Hope hull. (*via V. S. Gaunt*)

film. The interior of the hull was finished with Rylard white enamel. The increased depth of the Kingston Mk II hull necessitated the fitting of extension pieces to the wingtip floats. Possibly, the superstructure made for N9712 with the wooden hull was used in the manufacture of the metal-hulled version, but no definite proof of this exists.

Construction of the metal hull was undertaken at Preston. The hull's stucture, strangely enough, closely followed that developed by Linton Hope and in adopting this method a mistake may have been made, for the hull was later criticised for being overweight. Quite simply the various components of the Linton Hope hull—frames, keelson, longerons, stringers, timbers and floors—had been replaced by their metal equivalent. Final assembly of the Kingston Mk II was done at Lytham. After preliminary trials at Lytham, the flying-boat was delivered by air to the MAEE, Felixstowe. Piloted by Flt Lt B.C.H. Cross and with a Service crew on board, the Kingston left Lytham at 8.45 am on Saturday, 12 December, to arrive at Felixstowe on 14 December at 3.00 pm, halting en route for the whole of Sunday at Plymouth—a flight totalling 850 miles. By 4 June, 1926, N9712 had completed its official trials in the hands of Flg Offs L. Martin and W.E. Dipple. The Kingston Mk II was retained at Felixstowe for experimental flying and was known to be still flying in October 1927. The trials revealed several inadequacies in its performance: it was thought that the aircraft did not attain the standard set by the Kingston Mk I, and fell below par in respect of climb and alighting speed.

In the air, the stability and control were found to be satisfactory with the exception of the rudder, which felt slightly overbalanced and, in bumpy weather, snatched at the rudder bar. On the water, the control for taxi-ing was considered to be normal but when taking off there was a lack of elevator control and the hull took charge. There was also a marked tendency for the machine to porpoise and the take-off was generally sluggish. Early in 1930, N9712's metal hull was delivered to the Mechanical Test Department at RAE, Farnborough. There it was subjected to the tests devised for its wooden-hulled namesake. In November 1930, R & M 1398: *A Method of Testing the Strength of Aircraft Hulls*, was published based on the results of the tests on the metal hull. The report suggested that the hull 'should now be cut up and that various sections similar to those which have failed in compression, but which are still not too badly damaged in the tests already made, should be tested in direct compression to find out if they will give results which correspond closely with those obtained from the tests of the complete hull.' No doubt this suggestion was put into effect.

The last Kingston to leave Lytham foreshadowed the closure of the aircraft department of English Electric. This machine, designated Kingston Mk III and bearing the serial N9713, was built to the same contract as the Mk I, and it made its appearance early in 1926. The aircraft reverted to a wooden hull, but it was of a completely new design, characterised by a high, straight stem and deep forebody: the planing bottom was deep but relatively narrow. The hull was experimental, both in design and in the method of construction, although the construction followed closely that of the Gosport Aviation hull made for the Fairey Atalanta II. The Kingston Mk III had the same wings and tail unit as its predecessors, but the engine nacelle gun positions were abandoned, being replaced by small streamlined fairings. The flying-boat was intended to have upper-wing gunners' positions for the inner rear interplane-struts were fitted with steps. In fact, the gun nacelles, together with a modified upper-wing, had been completed and were ready for assembly on 30 January, 1926. Each nacelle was to



Kingston Mk III N9713 at Felixstowe in 1926. (*via RAE Farnborough*)

carry two gunners each armed with a single Lewis gun. Another nacelle was made, incorporating a single gun position aft of a 400 Imp gal petrol tank. This was to be positioned on the aircraft's centre-line slung beneath the upper-wing and replaced the outboard upper-wing gun positions and the two petrol tanks normally fitted. The fuel tanks and all metal fittings were of stainless-steel.

On 16 March, 1926, the Kingston Mk III left Lytham for Felixstowe, where it underwent official trials in the hands of Flg Off L. Martin. It flew to Felixstowe round the coast, stopping at Pembroke, Plymouth and Calshot. N9713 proved to be the most successful of all Kingstons, comparing equally in speed with the others, but having a superior rate of climb. The hull, also, proved to be cleaner running, the take-off was cleaner and there was no tendency for the machine to porpoise. The construction and lines of the hull were praised: its rigidity and robustness giving promise of good durability—the hull had remained extraordinarily watertight, no leakage occurring in the 70 hours of flying accumulated during the trials and on its delivery to Felixstowe. The Kingston Mk III was retained at Felixstowe for experimental work and, on occasion, for ferrying Service personnel. A particular instance of the latter being when it was flown by Flt Lt G.E. Livock, accompanied by Flt Lt Sawyer and Flg Off Martin, to Brough on 13 April, 1926, to report on the condition of the slipway and facilities for handling the Blackburn Iris.

A Kingston Mk III with an all-metal hull would have been built but for the closure of the aircraft department of English Electric, which was announced on the day that N9713 left Lytham for Felixstowe. Whether more Kingstons would have been built remains unknown, although there were rumours said to have emanated from official sources that an order was pending. However, it was decided not to put the Kingston into production. The order for a coastal patrol flying-boat was given to Supermarines for their Southampton.

Span: upper wing 85 ft 6 in, lower wing 63 ft 7 in; overall length: Prototype and Mk I 52 ft 9 in, Mk II 54 ft 4½ in, Mk III 57 ft 1½ in; hull length: Prototype and Mk I 45 ft, Mk II 46 ft 7½ in, Mk III 49 ft 4½ in; hull maximum beam across chines: Prototype 7 ft 7 in, Mk I 8 ft, Mk II 8 ft 3½ in, Mk III 8 ft; hull maximum depth: Prototype and Mk I 6 ft 2½ in, Mk II 7 ft 2⅛ in, Mk III 6 ft 10 in; height: Prototype and Mk I 20 ft 11 in, Mk II 21 ft 10½ in, Mk III 21 ft 6½ in; chord both wings 9 ft; dihedral: outer upper wing 3°, lower wing 0°; incidence both wings 4°; tailplane span 24 ft 9 in; tailplane chord including elevator 8 ft 6½ in; aileron span each 32 ft 9 in; aileron chord 2 ft 4 in; elevator span 24 ft 9 in; elevator chord 2 ft 9 in; upper wing area including ailerons 749.9 sq ft, lower wing area 532.6 sq ft; tailplane area including elevator 137.55 sq ft; aileron area 147 sq ft; elevator area 53.24 sq ft; fin area 55.31 sq ft; rudder area 37.95 sq ft.

	Mk I	Mk II	Mk III
Empty weight	8,739 lb	9,264 lb	9,559 lb
Weight of bare hull	1,603 lb	1,990 lb	–
Tare weight	9,130 lb	9,663 lb	9,868 lb
Normal all-up weight	14,508 lb	14,961 lb	14,981 lb
MAEE, Felixstowe Report No.	F/8	F/18	F/20
Report date	6 Nov. 1924	4 June, 1926	–
Kingston serial No.	N9709	N9712	N9713
Trials all-up weight	14,117 lb	14,117 lb	14,117 lb

	Mk I	Mk II	Mk III
Speed at sea level	104.8 mph	103.5 mph	104.8 mph
1,000 mph	104.2 mph	103.3 mph	104.0 mph
2,000 mph	103.4 mph	102.8 mph	103.6 mph
3,000 mph	102.7 mph	101.3 mph	102.8 mph
5,000 mph	101.3 mph	100.2 mph	101.0 mph
6,500 mph	100.1 mph	97.9 mph	98.0 mph
Climb to 1,000 ft	2 min 17 sec	2 min 27 sec	2 min 1 sec
2,500 ft	6 min 14 sec	6 min 38 sec	5 min 24 sec
3,000 ft	7 min 35 sec	8 min 13 sec	6 min 40 sec
5,000 ft	14 min 20 sec	15 min 41 sec	12 min 37 sec
6,500 ft	20 min 51 sec	23 min 12 sec	18 min 30 sec
Service ceiling	9,060 ft	8,310 ft	9,180 ft
Absolute ceiling	11,530 ft	10,870 ft	11,300 ft
Take-off run	1,155 ft	1,110 ft	1,140 ft
wind speed	10.9 mph	11.5 mph	10.9 mph
time	–	24 sec	23.8 sec
Alighting run	612 ft	345 ft	762 ft
Wind speed	–	11.5 mph	10.9 mph
True alighting speed	66.8 mph	69.1 mph	68.5 mph

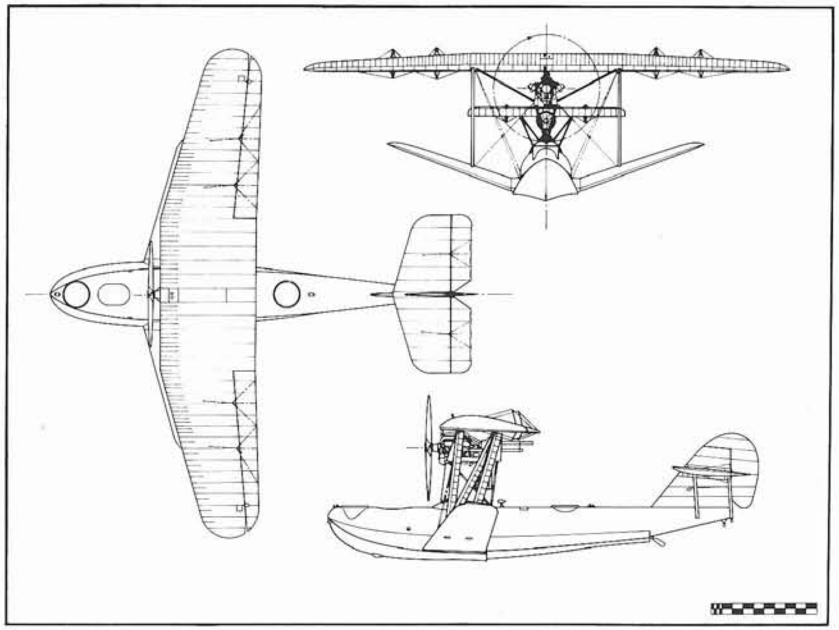
The only Ayr to be completed, photographed at Lytham on 10 February, 1925. (*The English Electric Co Ltd*)

English Electric M.3 Ayr

Early in 1921, W.O. Manning started work on a design for a flying-boat which incorporated several technically and aerodynamically attractive features. The design, known initially as the English Electric M.1 and later as the M.3 Ayr, was evolved from an official requirement for a single-

engine Fleet gunnery and spotting aircraft with a crew of four, three Lewis guns, and an all-up weight of about 7,000 lb. The aircraft was officially considered to be experimental, and on this basis contract No. AM/241097/21 was placed with English Electric for two prototypes, N148 and N149, each to be powered with a 450 hp Napier Lion IIb.

The Ayr was a biplane with highly-swept lower wings, having pronounced dihedral, attached so as to form a lateral extension of the forward planing surface of the Linton Hope-type hull. The lower wings, also built on the Linton Hope-principle, acted as sponsons thereby eliminating the need for wingtip floats. For this wing arrangement and its use in providing lateral stability afloat, by effectively increasing the beam of the hull, Manning was granted patents 190,211 and 209,538 in 1922 and 1924 respectively. The negatively-staggered upper wing had no dihedral and was cantilevered outboard of the N-shaped interplane-struts, the cantilever arrangement enabling external bracing-wires to be kept to a minimum. The little-known modified Durand 13 high-lift aerofoil section, developed in the USA, was adopted for the upper wing, which had ribs of Warren-girder construction placed in compression, so that the more usual drag-struts could be dispensed with. Leading and trailing edges were built up from stringers covered with birch plywood which was also used to cover the upper leading surface of the wing as far aft as the front spar. Both the ribs and the box-section spars, on which they were carried, had been subjected to structural tests undertaken in 1923 by the RAE, when they were found to be in excess of strength requirements. Similar tests were conducted by English Electric on the lower wing-fuselage joint, these being



English Electric M.3 Ayr.

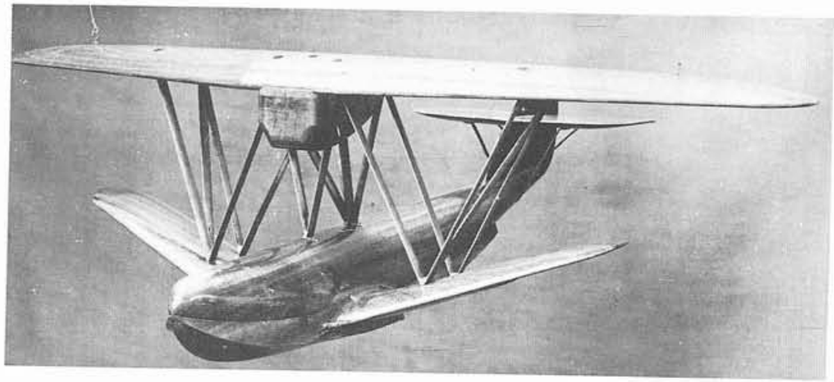
made in situ on one of the Ayr hulls under construction at the Dick, Kerr Works. The lower wing, which had an aerofoil section approximating to that of the upper wing, was also built up on two box-spars and was divided into watertight compartments vented to atmosphere. Ailerons of composite construction were fitted to the cantilevered portions of the upper wing, the arrangement of their hinges being the subject of Manning's patent 206,562 granted in 1922. The tailplane, which had an inverted AD No.1 aerofoil section (developed primarily for propellers), was constructed in a manner similar to the upper wing but was made in two sections bolted together on the centre-line. The elevators, and horn-balanced rudder, however, were of spruce and welded-steel composite construction, the elevators having balloon-cord trailing-edges. The tailplane could be trimmed hydraulically with Manning's patented gear. Henry Knowler, who had assisted Manning with the design of the Ayr, summarised its constructional advantages by noting:

a) 'If ordinary wing bracing had been used it would necessitate at least a two bay wing and overhang construction.
b) No wingtip floats with saving in weight and head resistance.
c) At least 4 ft is saved in overall height of machine with the advantage also that the centres of gravity, resistance and thrust are brought clear together.'

The crew comprised pilot, wireless operator, observer/gunner and gunner, all of whom entered the hull by way of the large cut-out immediately aft of the bow gunner's position. The pilot was seated in a raised position amidships, the wireless operator sat within the hull and the observer operated his camera from the cut-out. A single Lewis gun was mounted on a Scarff ring at the bow position and twin Lewis guns were provided for the rear gunner. The official specification initially called for one Vickers gun in place of the twin Lewis guns. A proposal was made to incorporate the Vickers gun, however, on a fixed mounting placed within easy reach of the pilot. The proposal was not embodied. 3,000 rounds of ammunition were carried and wireless completed the Ayr's operational equipment.

Petrol was gravity fed to the Lion engine from a 20 Imp gal tank carried between the upper wing centre-section spars. The gravity tank was primed by means of a wind-driven Rotoplunge pump from two 80 Imp gal tanks situated within the hull behind the pilot. Oil was carried in a cylindrical tank aft of the engine and a water tank was mounted in the wing leading-edge above the engine.

Before work started at English Electric's Dick, Kerr Works on the construction of the two prototypes, a $\frac{1}{12}$th-scale model of the Ayr in its initial form, the M.1, was subjected to many hydrodynamic and a few aerodynamic tests at the NPL. The water tests, which involved thirteen forms of hull with various lower wing settings, were conducted at the William Froude tank, the results being noted in test report EMK/15, dated 11 July, 1921. The form of hull finally evolved resembled its full-scale counterpart except in two notable respects—the inboard leading-edge of the lower wing was extended forward and faired to the hull, and the undersurface of the lower wing adjacent to the hull was built up to form a distinct planing surface. Although measurements were made of water resistance, power required for take-off, and longitudinal and lateral



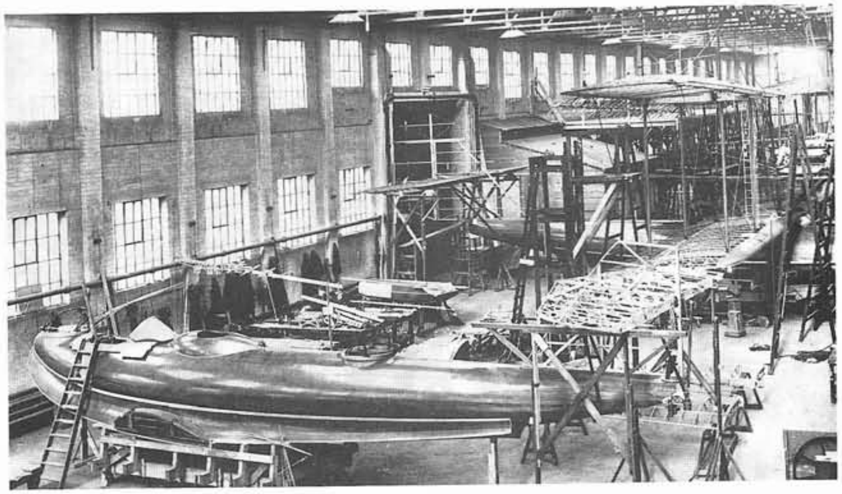
Wind-tunnel model of the English Electric M.1 from which the Ayr was developed. (*via W. Garlick*)

stability, it appears that no consideration was given to directional stability, even though it was noted that the model at the start of a test rested with one wing partially submerged and did not right itself until well underway. It was evident that the drag on the submerged wing would be considerable and would present problems in taxi-ing the full-scale machine for take-off, but this factor was overlooked. However, the final model form of hull-wing combination was incorporated in a wind-tunnel model, which was tested in Channel No.3 at a wind speed of 60 ft/sec and for a range of upper wing incidence of -8° to 22°. Measurements of lift, drag and pitching moment were made. The report of the test, published by W.L. Cowley in August 1921, concluded: 'The model results show that the maximum lift coefficient for the wings, due to the large camber, is high, and that the machine is fairly stable. Otherwise the results are normal.'

The results appeared promising, taken at face value, and the information was incorporated in refining the design, an intermediate stage, known as the M.2, being an attempt to make the aircraft amphibious by incorporating two wheels within the hull so that they projected just below the forward planing surface near the step. A retractable undercarriage outside the hull was considered as an alternative. The most noticeable changes to the design were: the elimination of the lower wing's root leading-edge extension and planing surface, the latter being replaced by the lower wings themselves; redesign of the V-formation of interplane struts to N-formation; and reshaping of the fin and rudder, of rounded appearance on the M.1, to more rectangular lines on the M.2, the form finally adopted being fitted to the Ayr.

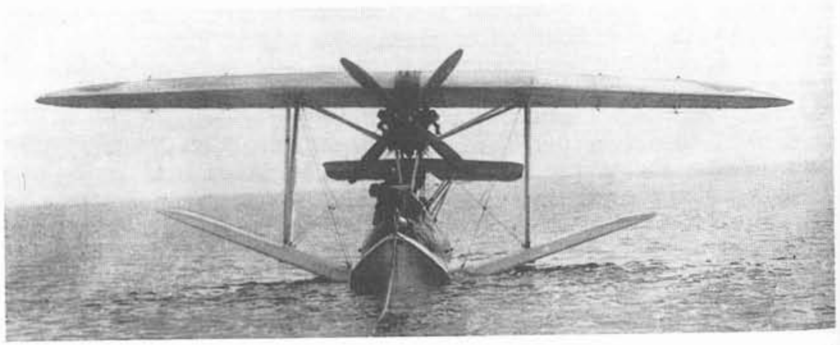
Shortly after the model tests, work began on the construction of a wood and canvas mock-up of the M.1 design. The mock-up was still in existence at the start of prototype construction in 1923.

Production of the two prototypes proceeded simultaneously but took second place to work on the Kingstons. Consequently, the prototypes did not reach the final stages of assembly until late 1924, even then only N148 was completed, N149 remaining unfinished at the closure of the aircraft department in 1926.



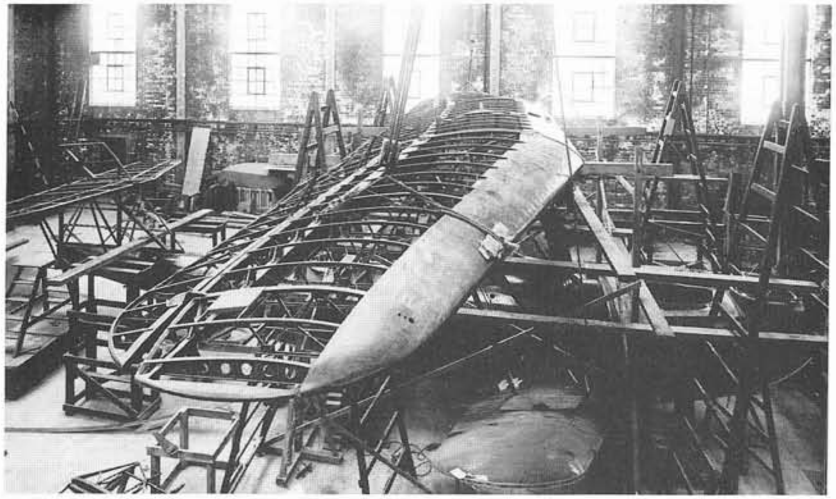
Construction of the first Ayr taking place concurrently with that of the prototype Kingston at Preston. (*The English Electric Co Ltd*)

The Ayr N148 made its début at Lytham, where it had undergone final assembly, on 10 February, 1925. In the following month, on 10 March, the Ayr was launched from the slipway at Lytham. As predicted by the model tests, the flying-boat immediately rolled to one side and floated with its lower wing just below the surface. Marcus Manton, who piloted the Ayr on this and subsequent occasions, gradually opened up the throttle and slowly taxied seaward. Taxi-ing proved difficult as the machine rocked about its keel submerging each lower wing in turn. With increasing speed, hydrodynamic lifting forces on the submerged wing became more pronounced and at 10 mph the wing shot out of the water, allowing the Ayr to continue planing on an even keel. It proved more difficult to keep the machine on a straight course, however, despite the fact that a water rudder had been fitted at the base of the second step. Manton found that



The Ayr at anchor. The use of the lower wings as sponsons can be clearly seen. (*via V. S. Gaunt*)

the situation did not improve at higher speeds but he was able to maintain a course sufficiently straight for take-off. Unfortunately, at high speed, water thrown up from the bows submerged the lower wings causing the machine to dive. Immediately the engine was throttled back. More attempts were made to take-off but all ended in much the same way. A little later, trials were conducted with the hull ballasted to settle it lower in the water. The Scarff rings were also removed, possibly to reduce drag, although at this stage they may have been considered unnecessary items of equipment. The Ayr still refused to take-off however.

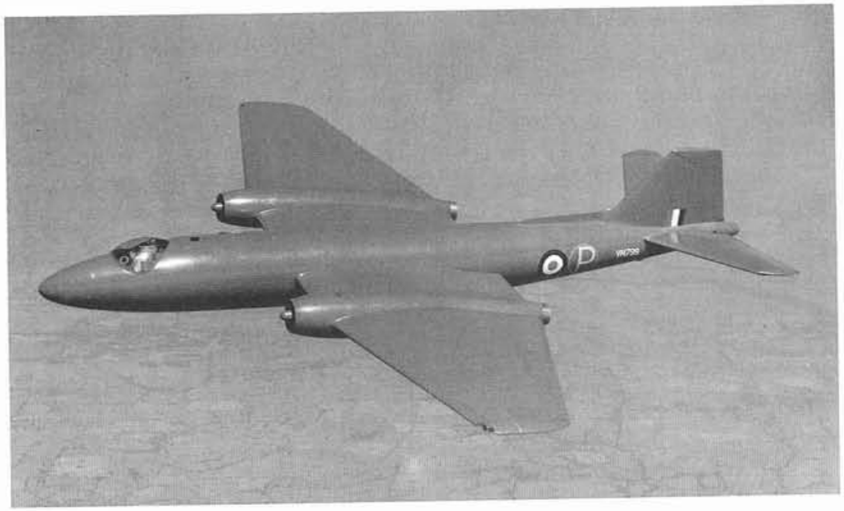


The second Ayr at Lytham. Construction was halted at this stage. (*The English Electric Co Ltd*)

The lack of success with N148 almost certainly led to a decision to halt production of the second prototype.

Sometime during the last days of English Electric's aircraft department, arrangments were made for one of the Ayr hulls to accompany the Kingston hull allocated for structural testing at RAE, Farnborough. In 1931, the Ayr hull and that of the Kingston were moored on the Basingstoke Canal and later towed to Greatbottom Flash, Ash Vale. In the early 1950s the Ayr hull sank, the result of the depredations of time. The fate of the sister hull remains unknown.

Span: upper wing 46 ft, lower wing 30 ft; overall length 40 ft 8 in; height 13 ft 8 in; hull length 38 ft; hull maximum beam across chines 6 ft; hull maximum depth without fairing 5 ft; root chord: upper wing 9 ft, lower wing 6 ft; tip chord: upper wing 5 ft, lower wing 4 ft; dihedral: upper wing 0°, lower wing 20°, incidence both wings 2°; leading-edge sweep both wings 16° 10′; negative stagger 2.4 ft; tailplane span 14 ft 10 in; tailplane root chord including elevator 7 ft 6 in; tailplane tip chord including elevator 5 ft 3 in; aileron span each 15 ft 10 in; elevator span 14 ft 10 in; elevator chord 2 ft; upper wing area 346 sq ft; lower wing area 120 sq ft; tailplane area including elevator 88.5 sq ft; elevator area 30 sq ft; fin area 33.9 sq ft; rudder area 22.5 sq ft.
Estimated weight empty 4,406 lb; bare weight of hull 1,086 lb; all-up weight 6,846 lb.
Estimated maximum speed at sea level 127 mph; estimated service ceiling 14,500 ft.
Price each £9,550.

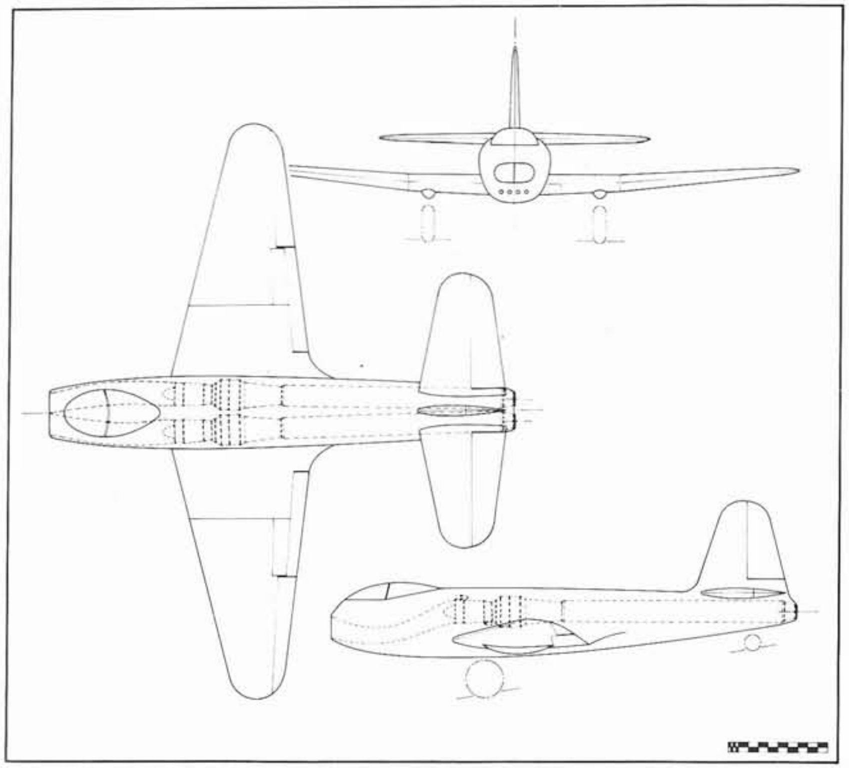


The prototype Canberra, VN799, with Roland Beamont at the controls, during an early test flight. The top of the rudder has the modified shape introduced after the first flight. (*British Aerospace*)

English Electric Canberra

Early in 1944 the controller of research and development at the MAP, Sir Ralph Sorley, suggested to W. E. W. Petter that he should investigate the feasibility of using a jet-engined aircraft for a fighter-bomber role. At that time Petter was technical director of Westland Aircraft. By March 1944, Petter and his team had completed the initial design of a relatively large fighter-bomber, which was to be powered by two Metro-Vickers turbojets. Provision was made for a variety of weapons to be carried internally, and various gun installations were proposed. The Air Ministry showed definite interest in the design. However, during the summer of 1944 Westland Aircraft was taken-over, and the new owners decided that work on the fighter-bomber should cease. Petter had by this time come to believe in the feasibility of the aircraft, and when he was unable to reverse the decision, he resigned his position at Westland Aircraft.

The Air Ministry continued to show interest in the fighter-bomber, and suggested that Petter and English Electric should get together with a view to continuing work on the aircraft. The outcome of this suggestion was that in July 1944 Petter joined English Electric as chief engineer of the Aircraft Division at Preston. His first concern was to build up a design team at the company design centre, which was housed in premises known as TC in Corporation Street, Preston. Petter and his newly formed team continued work on the fighter-bomber project, although the design was modified when the Air Ministry decided that the aircraft should be used as a high-altitude light bomber. The changes were not extensive, the most significant being the removal of the fixed internal guns.



Westland twin-jet fighter-bomber (March 1944).

The basic requirement was for an aircraft to replace the Mosquito in its high-altitude unarmed bomber role. In order to fulfil this role, a range of 1,600 miles with a 6,000 lb bomb load was called for, and also a cruising speed of 500 mph at altitudes in the range 35,000 ft to 45,000 ft. After studying numerous configurations, Petter's team had, by May 1945, decided that a single-engined mid-wing monoplane was the best layout. The wing was unswept and of particularly low aspect ratio. The large turbojet engine was to be housed in the rear part of the relatively slim circular-section fuselage with the bomb-bay in the lower forward fuselage. Provision was made for a crew of two, who could be seated back-to-back or side-by-side. This early standard of the aircraft had a distinct resemblance to the final Canberra design, the fuselage and tail surfaces in particular being close to their final configurations. During the initial layout work the choice of wing and engine characteristics was found to be the most critical factor in achieving a design to meet the requirements.

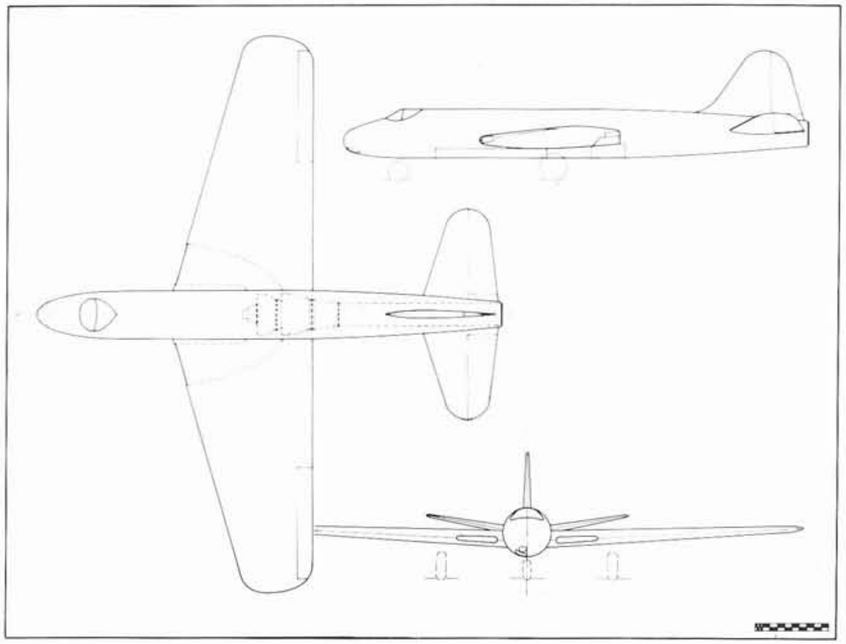
The combination of speed and height in the cruise condition resulted in flying at Mach 0.76, and this fact dictated the basic wing design. Flight at this Mach number limited the maximum thickness-to-chord ratio to 12 per cent, and prevented the use of a cambered wing section. This fact in turn limited the lift coefficient obtainable to relatively modest values, which

The first five production variants of the Canberra. Furthest from the camera is a B.2 (WH715); then in order are a PR.3 (WE135), a T.4 (WH846), a B.6 (WJ755), and a PR.7 (WH797). During 1953 B.2s started to be finished silver overall, and all B.6s and PR.7s had this scheme. (*British Aerospace*)

resulted in induced drag being a small proportion of total aircraft drag. Since induced drag was to be comparatively unimportant, there was no particular aerodynamic benefit in selecting a wing span greater than the optimum for wing stiffness considerations. Consequently, the broad-chord wing had a moderate aspect ratio and an area which resulted in a relatively low wing loading. The broad chord of the wing and the desired maximum thickness-to-chord ratio permitted the main undercarriage to be stowed completely inside the wing. Although the wing was designed specifically for high-altitude flight, its characteristics contributed to particularly good low-speed handling qualities, and also good take-off and landing performance. That the choice of wing was correct was to be demonstrated in later years by a notable series of record point-to-point flights, and also by the outstanding manoeuvrability for which the aircraft became famous.

In 1945, the high-altitude bomber would have needed three of the most powerful jet engines then existing to attain the required performance. Assuming that these were to be installed in the fuselage, all the feasible arrangements would have resulted in an excessive fuselage cross-sectional area. Therefore, after discussions with Rolls-Royce, it was decided that the high-altitude bomber should have a single engine, which would be specially designed and provide over twice the power of any then available. The proposed engine was to have had a centrifugal compressor, which would have resulted in an engine diameter of 66 in. The static thrust developed was to have been 12,000 lb.

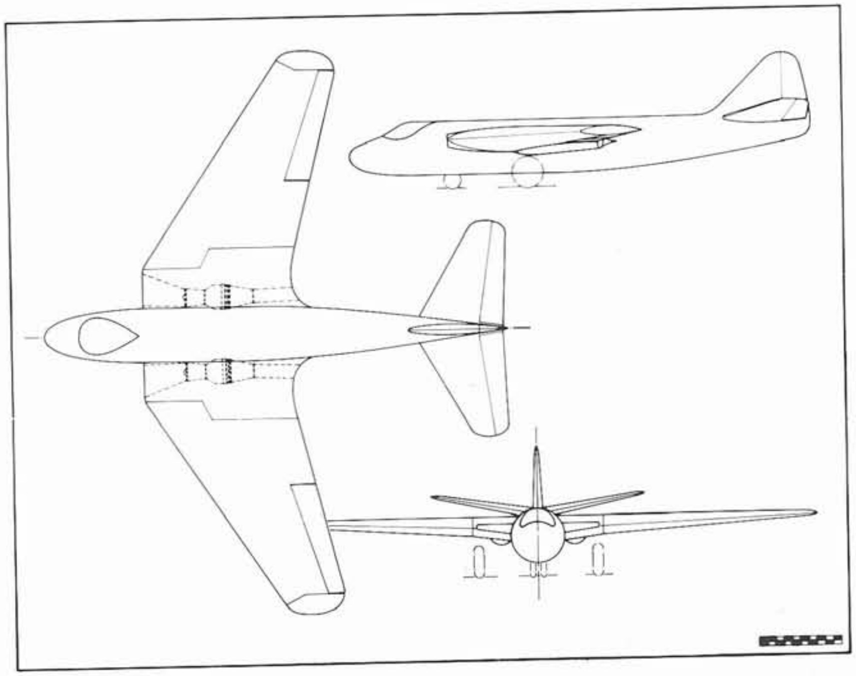
The proposal to use one large centrifugal engine, however, was overtaken after only a few months by the rapid pace of engine development. In July 1945, the design of the high-altitude bomber was



English Electric high-speed high-altitude bomber (May 1945).

changed to incorporate the new AJ.65 axial-flow turbojet then being proposed by Rolls-Royce. The AJ.65 was intended to have a static thrust of 6,500 lb, so that two would be needed by the high-altitude bomber. However, the inherent greatly reduced diameter of axial-flow engines compared with those with centrifugal flow resulted in the AJ.65 being slim enough to be installed in the wing root of the aircraft without serious thickening of the wing section in this region. This engine installation resulted in a more efficient layout of the fuselage, and the space available for the bomb-bay and fuel tanks was considerably increased. However, the AJ.65s were expected to have a specific fuel consumption up to 10 per cent less than the centrifugal engine previously considered, so that the fuel tankage requirements were actually decreased. Consequently, the space available for the bomb-bay was further increased, although the specified bomb load remained as before, being six 1,000 lb bombs. The enlarged bomb-bay did, however, permit the aircraft to carry larger bombs, and a single 8,000 lb bomb could be accommodated in the bomb-bay. The various design improvements permitted by the change to the AJ.65 engine resulted in a saving of over 10 per cent in the aircraft weight, which was decreased to 39,300 lb. This enabled the wing area to be reduced to 950 sq ft, without increasing the wing loading, and the aspect ratio was also slightly reduced, to a value of 4.9. The cruising speed was to be about 540 mph and the service ceiling just over 50,000 ft.

A result of obtaining data on the aerodynamics of flight at high subsonic speeds was that the design team also considered a 30° swept wing for the



English Electric high-speed high-altitude bomber (July 1945).

high-altitude bomber. Such a wing would have allowed an increase of about 35 mph in the maximum speed of the aircraft before the critical Mach number was reached. However, the swept wing would have introduced structural weight penalties and aerodynamic problems could have been encountered in its development. The design team, therefore, came to the conclusion that the use of a swept wing was not desirable, and the proposal was never seriously considered again.

The Rolls-Royce AJ.65 engine, later named the Avon, was to be the first

The first Canberra B.1 prototype, VN799, being towed out for its first engine runs on 2 May, 1949. (*British Aerospace*)

British axial-flow engine to enter large-scale production. The AJ.65 axial engine proposed by the Rolls-Royce engine development centre at Barnoldswick, in Yorkshire, was conceived specifically for the high-altitude bomber. When English Electric adopted the AJ.65 for its bomber, Rolls-Royce decided to develop the engine on a private venture basis and began detail design work in September 1945, the initial objective being to produce four prototype engines.

The high-altitude bomber design was refined further when the engines were moved outboard and housed in circular-section nacelles built into the wing. This change simplified the wing structure as the engine was mounted forward of the wing main spar, the size of the unavoidable cut-out in the spar thereby being minimised, as only the engine jetpipe had to pass through it. Moving the engines outboard allowed the wheels of the main undercarriage to be retracted into the wing root, thereby making the best use of the deepest part of the wing. Positioning the engines in separate nacelles was the final significant configuration change made in the design of the aircraft.

A brochure describing the aircraft was prepared and submitted to the Ministry of Supply in the autumn of 1945 in response to specification B3/45. This specification called for a high-altitude bomber, which, however, was not to have a conventional bomb-aimer. A radar bomb-aiming system was to be developed for the aircraft, enabling bombs to be dropped blind from high altitude. In September 1945, a mock-up of the nose fuselage was built at TC, to check the seating positions for the pilot and navigator, the layout of their instruments, and the installation in the nose of the scanner for the radar bombing system.

The submission of the brochure resulted in a contract, dated 7 January, 1946, for the detail design of the aircraft, and the manufacture of four prototypes. These became known as the English Electric A1. This designation was derived from the SBAC numbering system, which was used for drawings for the prototype aircraft and later variants. Drawing numbers for the four prototypes were prefixed EA1. Under this system 'E' was allotted to English Electric, and 'A1' indicated the first block of numbers to be used in the system. Later variants of the aircraft, after the initial prototypes, used blocks of numbers prefixed EA2, EA3, etc, but the designations A2, A3, etc, were not used as the aircraft had by then been named Canberra.

Detail design of the A1 by Petter's team at TC began early in 1946, and progressed steadily during the year. As well as working on the basic design, the team also considered variants. In October 1946, the first of a number of studies of proposed civil transport derivatives of the A1, and later the Canberra, was made. The first proposal was for an airliner which would have carried 34 passengers up to 930 miles, or 16 passengers up to 1,600 miles. The passengers were to have been carried in a circular-section pressure cabin 10 ft in diameter, the seating generally being four abreast. A rudimentary form of containerized baggage stowage was proposed; this was a practice which was not to be seriously used for about another 20 years. The transport would have had similar engines to the A1, although for take-off temporary thrust-boosting was proposed. Cruising speed would have been 450 mph. If it had been built, it would have been in competition with the de Havilland Comet.

It was during the development of the A1 for other roles that the great potential of the design quickly became apparent. In August 1947, a brochure was prepared which described two firm proposals for new variants of the aircraft, and also suggested a possible third. However, this brochure also proposed significant improvements to the basic A1 high-altitude bomber. The first of these improvements was to make provision for the carrying of one 10,000 lb bomb, although the standard load remained six 1,000 lb bombs. The increase in weight when carrying the single large bomb had little effect on performance, the most important result being a reduction in range of 100 miles. To compensate for this, and also to increase the standard range, the second improvement provided for a drop tank, containing 250 Imp gal, to be carried at each wingtip. These tanks enabled the range to be increased by 600 miles to 2,400 miles. For ferrying purposes, the range could be increased further by installing auxiliary fuel tanks in the bomb-bay. With this large quantity of fuel on board, the range of the aircraft was estimated to be 4,000 miles, and the maximum endurance nearly 10 hours.

The first of the new variants of the aircraft was a photographic reconnaissance version, to specification PR31/46. In most respects similar to the basic A1, the reconnaissance aircraft was, however, to be modified in the region of the fuselage nose and in the bomb-bay. A third crew member, an observer, was to be carried, and the extreme nose glazed to permit visual sighting for photography. A maximum of eight cameras were to be mounted in two compartments, one at each end of the bomb-bay. The forward part of the bay was converted into another fuel tank, the extra capacity of 400 Imp gal enabling a range of 3,050 miles to be achieved. The rear part of the bomb-bay was to contain flares.

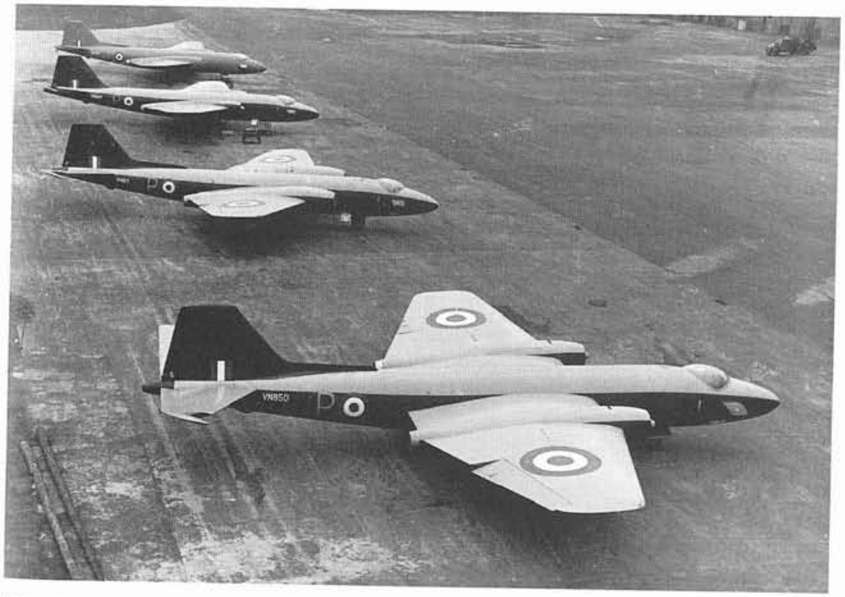
A low-altitude tactical bomber to meet specification B5/47 was also proposed. This aircraft differed very little from the basic A1, the principal change being the replacement of the radar bomb-aiming equipment by its manual equivalent. A third crew position, for the bomb aimer, was provided, and the bomb sight was positioned in a glazed nose similar to that of the PR31/46 aircraft. The standard bomb load was increased to 7,500 lb, and the cruising altitude reduced to 20,000 ft. These two changes resulted in greatly increased fuel consumption, so that, since fuel capacity was not increased, the range of the aircraft was only 970 miles. By the summer of 1947, it had become apparent that the radar bomb-aiming equipment for the high-altitude bomber was likely to be delayed, and English Electric proposed that the first production variant should be the tactical bomber, with the high-altitude aircraft entering production when the radar equipment was available.

The third variant of the A1 proposed in August 1947 was a conversion and navigational trainer, but at that time only initial investigative work concerning this was undertaken.

Detail design of the A1 continued during 1947, a full-scale mock-up of the complete aircraft being built at TC early in the year. The first bench running test of the AJ.65 engine was made by Rolls-Royce at Barnoldswick on 25 March, 1947. By this time the Ministry of Supply was funding development work, and the engine had been named the Avon, the first experimental engines being designated Avon RA.1. The early tests showed that the axial-flow compressor suffered from stability problems,

and many months of development effort were needed to overcome these difficulties. So persistent were the problems that fears were aroused that the engine might not be available for the A1 when it was ready for flight. The decision was made, therefore, that the second of the four A1 prototypes should be fitted with two Rolls-Royce Nene engines. The Nene was a centrifugal-flow engine of proven reliability, but it did not provide as much thrust as the Avon. The installation of the Nene in one of the A1 prototypes would have enabled flight trials to have started on schedule if the Avon was delayed. If the Avon had proved a failure, an alternative power-plant installation would have been available without serious delay to the A1 development programme.

R.P. Beamont joined the English Electric Aircraft Division as chief test pilot in May 1947. His primary interest was the development of the A1, with particular emphasis on the layout of cockpit instruments and controls. In the summer of 1947 English Electric obtained a contract to investigate the effects of high altitudes and Mach numbers on aircraft handling and performance. For this work a Meteor F.4, EE545, was used, and experimental flying of this aircraft started in August. All the flights were made from Warton airfield, with Beamont as pilot. This series of flights produced valuable data on the effects of compressibility on the manoeuvrability of high-flying aircraft, this being particularly relevant to the design of the A1. During the course of the programme many flights were made at altitudes above 40,000 ft. The last experimental flight was made in July 1948.



The four B.1 prototype Canberras, with VN850 nearest the camera. Next is VN813, with Nene engines and modified nacelle shape without intake bullet. Behind is VN828, the first aircraft without a small dorsal fin. VN799, the first prototype, with a non-standard paint scheme, is furthest from the camera. (*British Aerospace*)

During 1948 two further series of experimental flights were made to obtain basic data as background for Canberra design work. In April the English Electric-built Halifax, ST808, was used to flight test a Servodyne powered elevator. The flights were made from Samlesbury, with Squier as pilot. The installation was found to be unsatisfactory, and was not adopted for the A1. The second series of flights was made with the Vampire F.3 VT861. This aircraft came off the assembly line at Samlesbury early in 1948, and was loaned to English Electric for trials work. In July and August Beamont flew the aircraft from Samlesbury on a number of high-altitude experimental flights, during which altitudes in excess of 40,000 ft were again attained. This aircraft was also used for some take-off and landing tests.

In the summer of 1948, the design organization moved from TC to Warton, where all research and development work became established. Two wind tunnels, for low- and high-speed use, were completed, and Canberra wind-tunnel testing, which had previously been done at Farnborough, became centred at Warton. The design team was then concentrating its efforts on the variants of the A1, and orders were received for four prototypes of the B5/47 bomber and one prototype of the PR31/46 photographic-reconnaissance aircraft. The decision to build the B5/47 variant had been made because it had become apparent that the radar bomb-aiming system for the high-altitude bomber was not going to be available, and that a conventional visual aiming system would have to be used. It was also decided to operate this aircraft at high altitude. Consequently, the four prototypes of the A1 to B3/45, without provision for a bomb aimer, came to be regarded as interim aircraft.

Testing of the Avon RA.1 engine by Rolls-Royce had, by late 1947, shown that a satisfactory initial production engine could be obtained by reducing the engine mass flow. The modified engine was designated the Avon RA.2, but owing to the reduced mass flow the thrust produced was only 6,000 lb, 500 lb less than the RA.1 engine. The first RA.2 engine was bench run in January 1948, and development progressed smoothly during the year. In August the Avon RA.2 flew for the first time when two engines were tested in the Lancastrian test-bed aircraft VM732. Five weeks later Beamont flew the test-bed aircraft to obtain experience of handling the Avon engine, in preparation for his forthcoming flight testing of the A1 prototype.

The A1 was a closely guarded secret until after flight testing had begun, but during 1948 rumours were circulating that English Electric was building an aircraft of its own design. One of these rumours, based on an incorrect interpretation of facts, said that an 'electric bomber' was being built. During the Parliamentary debate of the Air Estimates in March 1949, the Secretary of State for Air announced that a twin-engined jet bomber with a speed nearly twice that of current bombers had been ordered in quantity. This statement was the first official reference to the A1, although the manufacturer and type were not specified.

The order referred to in the Air Estimates debate was received by English Electric in March 1949 and was the first production order for developments of the basic A1. A total of 132 aircraft were covered by the contract, comprising ninety B5/47 bombers, thirty-four PR31/46 photographic-reconnaissance aircraft, and eight trainers. The trainer aircraft was

the variant first proposed in August 1947, and was to specification T2/49. Ordering a new aircraft into quantity production before the prototype had flown was not the usual practice. However, the tense international situation, known as the 'Cold War', had caused Britain to start expanding and re-equipping her armed forces. Re-equipment of the bomber units of the RAF was particularly urgent since their aircraft were quickly becoming obsolete.

During the spring of 1949 manufacture of assemblies for the first A1 prototype was completed. Parts made at TC and Strand Road were fully assembled at Strand Road, for check functioning of the airframe. After satisfactory checks, the airframe was dismantled and transported to Warton, for reassembly and flight testing. At this time English Electric was using only one hangar at Warton. A low-speed wind-tunnel and a test frame were housed at one end, whilst the other end was to be used as a flight hangar for the A1 prototype. Early in 1949 Rolls-Royce built a semi-production batch of Avon RA.2 engines, and two of these were supplied to English Electric for installation in the first aircraft.

The first A1 prototype, VN799, was rolled out for the start of engine running tests on 2 May, 1949. By 8 May, these tests were satisfactorily completed, and the aircraft was ready for Beamont to start taxi-ing trials. Two series of taxi runs were made on 8 May, followed by further runs on 9 May, in the course of which the aircraft was briefly airborne in short hops within the length of the 1,900 yards-long main runway. High speed taxi-ing runs continued on 11 May, and on the following day the final tests were made before the first flight. The last test was a hop of 500 yards at a height of 15 feet, during which the response to aileron movement was tested, and found to be satisfactory. It might be said that after having been airborne, the aircraft had made its first flight. However, the hops were not regarded as true flights, although they did enable Beamont to evaluate response to aileron and elevator control and obtain a 'feel' for the aircraft.

VN799 was ready to fly on 13 May, 1949. This date was a Friday, so that the dubious combination of Friday the 13th was produced. Petter suggested to Beamont that this was not perhaps a suitable day to attempt

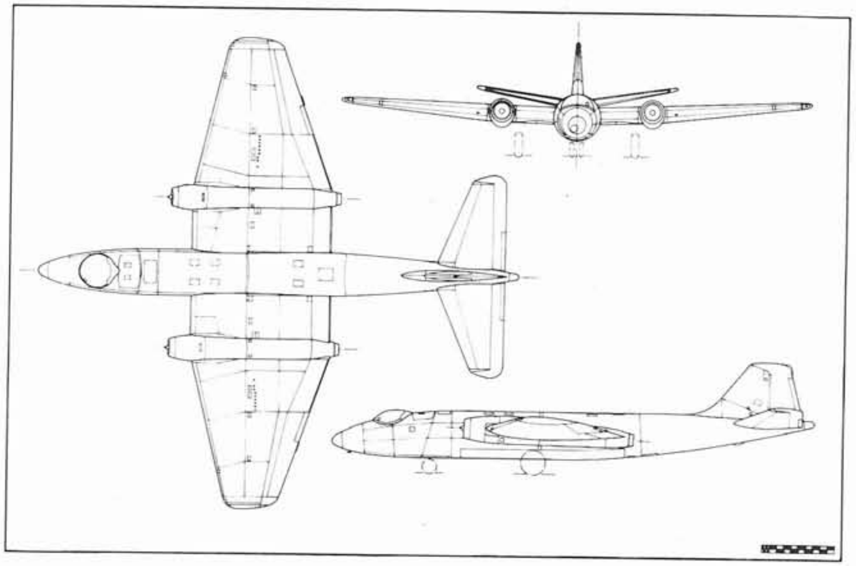
Not the first flight, but the last of a number of hops made by Canberra B.1 prototype VN799 on 12 May, 1949, the day before the first flight. The rudder has a rounded top. (*British Aerospace*)

such an important step as the first flight, but Beamont replied that since the aircraft was ready, and the weather was perfect, the day was as good as any other. As Beamont taxied out in VN799 for the first flight, only 40 months had elapsed since January 1946, when English Electric had received the contract for the A1 prototypes. The flight was more important than most first flights by new types since the A1 was the only modern British bomber existing, and was urgently needed to re-equip RAF bomber squadrons. In addition, the A1 was the first and, at that time, the only product of the English Electric aircraft division. Failure of the aircraft would probably have resulted in the aircraft division having to be closed down. From Beamont's personal point of view, the A1 was the first type for which he had had the responsibility for making the first flight, so that the future prospects of his test-flying career largely rested on the success of the A1.

The first take-off was made at 10.46 on 13 May, 1949, and a Vampire piloted by Squier joined the A1 soon after take-off to act as chase aircraft during the flight. On reaching a speed of 170 mph and a height of 200 ft, Beamont checked aileron and rudder responses. The effects of aileron input were found to be satisfactory, but when rudder movement was tried, the response was jerky and non-linear. Beamont concluded that the rudder was probably over-balanced. Continuing to climb the aircraft, Beamont retracted the undercarriage, which quickly and smoothly stowed itself. The resulting reduction in drag necessitated a reduction in power in order to avoid exceeding the 290 mph airspeed limit set for the first flight. On reaching 10,000 ft Beamont was able to trim the aircraft to fly hands-off, and found that in cruising flight it flew remarkably quietly and smoothly. In order to confirm his earlier conclusion that the rudder was over-balanced, Beamont again tested the effect of rudder input, and experienced the same unsatisfactory results as before. However, all other controls were found to be satisfactory, and the fuel system and engines gave no trouble. Having completed the initial in-flight evaluation, Beamont turned VN799 towards Warton, where an uneventful landing was made after 27 minutes of flight.

Before the first flight, both test pilot and design team had had great expectations of the aircraft, but the actual results of the flight surpassed their most optimistic hopes. The one difficulty experienced, that of rudder over-balancing, was of a relatively minor nature, and could be easily rectified. In order to overcome this snag, the rudder horn-balance was reduced in area, and as a result the rounded top of the rudder became a less attractive square-cut shape. The effect of this modification was tested on the second flight, which took place five days after the first. Rudder behaviour was found to be entirely satisfactory, and flight trials progressed steadily thereafter without any serious problems being encountered. During the third flight a speed of Mach 0.77 was reached, which was close to the maximum design Mach number.

Following the successful first flight, the existence of the A1 was publicly announced, and photographs of the aircraft were published for the first time. The features of the A1 most immediately apparent were its unusually clean lines, and the pale blue overall colour scheme. This was a non-standard scheme, and was used only for two of the prototypes. The A1 was immediately hailed as one of the most elegant aircraft ever seen, since the



English Electric Canberra B.2.

canopy and engine nacelles, the only features to break the fine lines of the aircraft, were so smoothly faired that they did nothing to spoil the overall effect. The lines of the aircraft made it appear smaller than it actually was, and the particularly large wing chord caused the fuselage to appear deceptively slim.

The fuselage was divided into nose, centre and rear sections. The nose was largely occupied by the pressure cabin for the pilot and navigator. The pilot was seated off-centre to the left, under a one-piece bubble canopy, which provided very good visibility. The navigator's position was behind the pilot, but the only external vision was through a window in the fuselage side. Both crew members were provided with ejector seats. Entry to the cabin was through a hatch on the right-hand side. Immediately aft of the navigator's seat was the cabin pressure bulkhead, behind which was the nosewheel bay. The centre fuselage was basically a tube, most of the lower part of which was occupied by the bomb-bay. When the two large bomb-bay doors were opened in flight they were automatically partially retracted to reduce drag. Above the bomb-bay were situated fuel tanks which contained the whole of the aircraft's internal fuel. However the tanks were split in two by a bridge member, which was a heavy forged item onto which the wings were mounted. The tapered, circular-section rear fuselage carried the tail surfaces. These were of conventional layout, the only unusual feature being the provision for varying the incidence of the tailplane in flight.

The single-mainspar wing was of symmetrical section, the main attachment points to the centre fuselage being at the root of the main spar. A shear wall formed the rear of the wing torsion box, and the flaps and ailerons were mounted on this shear wall. The engine nacelle was built into the wing, the engine being mounted forward of the main spar. The jetpipe

passed through the main spar, there being a substantial ring fitting to carry spar loads round the jetpipe. Between the engine nacelle and the fuselage was the bay for stowage of the main undercarriage, which was of English Electric design and manufacture.

A few weeks after the first flight of the A1, the name Canberra was chosen for the aircraft, although the official naming ceremony did not take place until early in 1951. The four A1 prototypes, built to B3/45, became the Canberra B Mk 1. The prototypes of the production aircraft, to B5/47, became the B Mk 2, and the photographic-reconnaissance aircraft, to PR31/46, became the PR Mk 3. The fourth version on order, the conversion trainer to T2/49, was designated T Mk 4.

By the time of the 1949 Farnborough air show, in September, VN799 had made over 50 flights. These had included flights at the maximum design speed, and also at altitudes above 40,000 ft. Beamont's demonstration of VN799 at the show startled the spectators, who had been expecting the sedate type of display normally associated with bomber aircraft. Instead, they saw a display of speed, climb rate, and handling which compared well with the performance of the fighter types at the show. Referring to the Canberra, *Flight* commented that 'a new aircraft had never been more convincingly demonstrated'.

During November 1949, VN799 went to the A & AEE at Boscombe Down, for initial Service handling trials. Seven pilots flew the aircraft for a total of over 30 hours in the course of the trials, which lasted 18 days. The one hundredth flight by VN799 was made early in December, and about this time flying hours also reached 100. An automatic flight-test instrumentation unit mounted in the bomb-bay made an important contribution to the progress of flight-test work. This unit had 45 instruments mounted on a panel, which was photographed by still and cine cameras. By means of these cameras, the maximum possible amount of information was obtained from each test flight, thereby keeping to a minimum the number of flights necessary.

The second of the four B.1 prototypes, VN813, made its first flight on 9 November, 1949. This aircraft was powered by Nene centrifugal-flow engines. VN813 was used by English Electric for general development flying until late 1950, when the aircraft went to Rolls-Royce to be used for Nene engine development work. The third prototype, VN828, first flew on 22 November, 1949, and was similar to VN799. However, the initial flight was made from Samlesbury, where final assembly of the aircraft had been done. All subsequent prototype and production aircraft were assembled at Samlesbury, although until production was well established, flight testing was conducted at Warton. VN828 served with English Electric as a development aircraft for five years. The last B.1 prototype, VN850, first flew on 20 December, 1949, so that three prototypes had been completed in a period of six weeks. VN850 was again basically similar to VN799, but incorporated two changes. Provision was made for carrying wingtip auxiliary fuel tanks, and the small dorsal fillet in front of the fin was deleted. Experience with the earlier prototypes had shown this fillet to be unnecessary.

The first B.2 prototype, VX165, made a 45 minute first flight on 21 April, 1950, piloted by Beamont. Although the major difference between the B.2 and the B.1 was the provision for visual bomb-aiming, involving

The first Canberra B.2 prototype, VX165, with glazed nose for the bomb aimer, seen over the Lake District. (*British Aerospace*)

glazing of the nose and the addition of a third seat for the bomb aimer, several other significant improvements were featured in the B.2. The RA.3 engine replaced the RA.2, and provided 500 lb of extra thrust. Air-brakes and attachment points for wingtip fuel tanks were fitted as standard, although both features had been built into the last B.1 prototype, VN850. During the summer of 1950, VN850 was flight-tested with the wingtip tanks fitted, the first of these flights being on 11 May. On 31 July the tanks were successfully jettisoned for the first time, over the airfield at Warton.

As a result of the spectacular demonstrations of the Canberra at the 1949 Farnborough air show, interest in the aircraft during 1950 was considerable. VN850 attended the Paris air show in June, and went on to Antwerp to give further displays piloted as usual by Beamont. The most significant interest in the aircraft came from the United States, and in July VN850 was displayed to a United States Mission at Boscombe Down. In September, a high level delegation of Americans, led by General Boyd, USAF chief test pilot, visited Warton to conduct a detailed evaluation of the Canberra. After ten days of intensive test flying and technical examination, the Americans asked that arrangements be made for a Canberra to go to the United States for further evaluation. This request was not particularly surprising, since the Americans often showed a superficial interest in new British aircraft. However, towards the end of 1950 English Electric were startled to discover that the Americans were seriously proposing that the Canberra should be licence-built in the United States, subject to satisfactory evaluation there by the USAF for whom it was intended. The great significance of the American proposal can be seen from the fact that a British military aircraft had not been built in the United States for nearly 40 years. In addition, the Canberra had not at that time entered service with the RAF, or even completed acceptance trials. American faith in the Canberra was thus demonstrated to be as great as

that of the British, a state of affairs which was tremendously gratifying to English Electric!

Australia had first shown interest in the Canberra early in 1949, a considerable time before American interest had become apparent. During 1950, Australian interest increased, finally resulting in a decision to build the aircraft under licence in Australia. This decision, although most satisfactory from English Electric's point of view, was not of such great significance as the American choice of the Canberra, since Australia was a recognised market for British aircraft. Nevertheless, Australia had demonstrated great faith in the Canberra before the design was fully proven. The selection of the Canberra by two overseas countries at such an early stage of its development life augured well for the commercial success of the project.

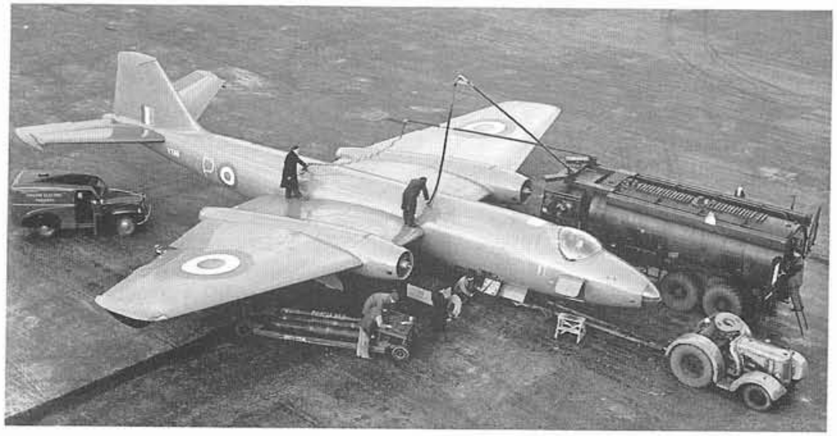
In June 1950 the tense international political situation was aggravated by the outbreak of the Korean War. The British re-armament programme was expanded and speeded up as a result, and the plans for Canberra production were among those to be revised. English Electric received its second production order in November, this order being considerably larger than the first placed 20 months previously. The contract covered 215 aircraft, of which 143 were B.2s, 35 were PR.3s and the remaining 37 were T.4s. Development of more advanced variants of the Canberra later caused some of the orders for B.2 and PR.3 aircraft to be changed to orders for later marks. During 1950, English Electric received a development contract for one prototype of the Canberra B.5 target marker variant, which was to have a number of important improvements over the basic B.2 production aircraft. This contract was indicative of the intensive development work that English Electric was engaged in to exploit fully the potential of the Canberra design.

The demand for Canberras for RAF re-equipment was, however, too great to be met by any one firm, and a sub-contract manufacturing programme was, therefore, initiated. The companies chosen for this work were Short Bros & Harland at Belfast, A.V. Roe at Manchester, and Handley Page at Cricklewood, North London. Each company received an initial order for one hundred B.2s, with the start of deliveries required to be about two years from the placing of the contract. Sub-contracting was introduced into Avon engine manufacture also in order to meet the demand of Avons to power the Canberra and other aircraft, one of the companies receiving sub-contracts was D. Napier & Son. All Canberras contained many items of electrical equipment made by English Electric, and in the case of an airframe built by English Electric and fitted with Napier-built engines, the proportion of the aircraft produced within the English Electric Group was very high indeed.

The year 1951 opened with the Canberra's official naming ceremony, which took place on 19 January at Biggin Hill RAF Station in Kent. The actual aircraft named was the first production B.2, WD929. Sir George Nelson, chairman of English Electric, had chosen the name Canberra in honour of the Australian capital, that country being the first export customer. The naming ceremony was performed by the Australian Prime Minister, the Rt Hon Robert Menzies. After declaring the aircraft to be named, Mr Menzies released a bottle of Australian champagne, which swung against the nose of WD929 and shattered. During rehearsals before

the ceremony the organizers had encountered an unexpected problem: champagne bottles had shown a worrying tendency to bounce off the Canberra's nose without breaking! However, the organizers found that they could ensure that the bottle would break by scratching it with a glass cutter. Accordingly, on the day of the ceremony a bottle was used which had been suitably weakened. Although it duly shattered most satisfactorily, the organizers had some anxious moments, as they feared that it might break before striking the nose of the Canberra! Among the large party of guests who attended the naming ceremony were several senior United States officials, indicating the continuing serious American interest in the aircraft. Indeed, early in 1951 many people regarded selection of the Canberra for the USAF to be a foregone conclusion, in spite of the fact that evaluation trials in the United States were not to take place until later in the year.

Production of B.2 aircraft was only one or two a month in the first half of 1951, but reached six a month at the end of the year. Although the operational squadrons of Bomber Command were eager to start re-equipping with the Canberra, very few of the early production aircraft were delivered to them. A few were used for official trials of the aircraft itself, whilst several others were allocated to English Electric for development work. However, over half of the aircraft built during the year went to Ministry and industry research and development establishments. Before the advent of the Canberra, no aircraft capable of prolonged high-speed cruise at altitudes above 40,000 ft had been available. Lack of such an aircraft was, in 1951, seriously hindering the development of engines and equipment intended for high-altitude flight. A number of these development programmes were judged to be of sufficient importance to justify allocating Canberras to them before making deliveries to Bomber Command. Examples of aircraft used for research work were the first production aircraft, WD929, which went to the Telecommunications Research Establishment, and WD947, which was used by the Royal



The Canberra PR.3 prototype VX181. This aircraft and VN799 were the only prototypes to have the non-standard overall blue paint scheme. Two camera windows can be seen just behind the open hatch near the nosewheel. (*British Aerospace*)

The Canberra B.5 prototype VX185 showing the unglazed nose. The longer bullet in the intake and the inscription on the nose indicate that the photograph was taken after the aircraft had been fitted with RA.7 engines and made the out and back crossing of the Atlantic. (*British Aerospace*)

Aircraft Establishment at Farnborough for meteorological work. Aircraft used as engine test-beds were WD930 and WD943 with Avons, WD933 with Sapphires, and WD952 with the Olympus. The use of Canberras in an extremely wide variety of research and development programmes was to continue for well over 20 years.

The prototype PR.3 reconnaissance aircraft, VX181, first flew at Samlesbury on 19 March, 1951, piloted by Peter Hillwood, who had joined English Electric as a Canberra test pilot. Further changes had, before the first flight, been made to the originally proposed layout of the PR.3. To increase range, the forward part of the bomb-bay was converted into an extra fuel tank, the remaining part containing flares. Seven cameras were mounted in a 14 in long section inserted in the fuselage forward of the wing. Only two crew members, pilot and navigator, were provided for, as the bomb-aimer was not needed.

On 6 July, 1951, the prototype B.5 aircraft, VX185, flown by Squier at Samlesbury, was the fourth Canberra variant to make its first flight in just over two years. The Canberra B.5 was intended for the specialist role of target marking, and was designed to specification B22/48. Although based on the B.2, the B.5 had several new features, of which the fitting of a bomb-aiming radar in the nose and the introduction of integral wing fuel tanks were the most significant. However, changing official requirements resulted in no production orders being placed for the B.5, and VX185 became a general development aircraft for the Canberra.

The aircraft which the Americans had requested for evaluation in the United States flew across the Atlantic on 21 February, 1951, and in so doing WD932 performed the first of the many record and notable flights to be made by Canberras during the 1950s. Flown by an RAF crew of three, of which the pilot was Sqn Ldr A.E. Callard, WD932 made the first direct non-refuelled Atlantic crossing by a jet aircraft, flying from Aldergrove in Northern Ireland to Gander in Newfoundland. Flight time was 4 hr 37 min, and the average speed was just over 450 mph, so that the flight was also the fastest Atlantic crossing ever made. However, since FAI observers had not timed the flight, an official record could not be claimed. A few days after arriving at Gander, WD932 was flown to Andrews Air Force Base, near Washington, where comparative demonstrations of the

Canberra and four American bombers were to take place. Beamont took over the aircraft for the demonstration from Sqn Ldr Callard. Under Beamont's control, WD932 gave a performance which completely outclassed the American aircraft taking part in the demonstrations. This triumph was the final factor which resulted in the Canberra being chosen for the USAF. In April 1951, an agreement was signed for the Canberra to be built under licence in the USA by the Glenn L. Martin Company, and the aircraft received the USAF designation B-57. Martin was the sixth organization to undertake manufacture of the aircraft, and the Canberra was to be the first British military aircraft built in the USA since the de Havilland D.H.4 in 1917. (The development and production of the Martin B-57 is described elsewhere in this book).

Further large orders for the Canberra were placed early in 1951. About one hundred and thirty B.2s, eighteen T.4s and forty PR.7s were ordered from English Electric, and Shorts, Avro and Handley Page each received orders for fifty B.2s. After these contracts had been placed, orders for Canberras from the four British manufacturers totalled nearly 1,000 aircraft. In the event, all of the 1951 production orders were to be cancelled or modified before manufacture began. Although contracts had been placed for production T.4 trainers, no prototype had been ordered. However, early in 1951 this situation was remedied when one T.4 prototype was ordered from English Electric, to be built as far as possible from production line components.

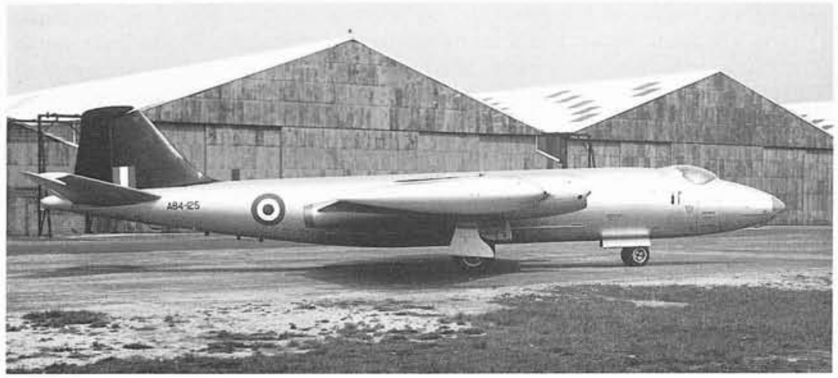
Delivery of Canberras to operational squadrons of Bomber Command began on 25 May, 1951, when Beamont flew WD936 to Binbrook to join No.101 Squadron. The Canberra replaced the Lincoln in 101 Squadron and also in most of the early squadrons to re-equip. No.101 Squadron Lincoln crews were replaced with specially chosen crews before the arrival of Canberras, and a conversion flight was formed at Binbrook to prepare them for the new aircraft. For initial jet conversion training the flight had two Meteor T.7 two-seat trainers, and for more advanced training two single-seat Meteor F.4 fighters were used. After about 15 to 20 hours of instruction in the Meteors, pilots went on to Canberra familiarisation in the single aircraft operated by the flight. About three hours in the Canberra was usually sufficient to qualify a pilot on the type. Soon after starting to receive Canberras, 101 Squadron began intensive flying trials of the type, flying its aircraft at several times the normal peace-time rate.

The first delivery to 101 Squadron had been made 24 months after the initial flight of the prototype, and in this period both the aircraft itself and the Avon engine had progressed from development to service status. Owing to many of the early aircraft from the production line being allocated to experimental work, deliveries to 101 Squadron were slow, and the unit was not fully equipped until December 1951. The first aircraft delivered suffered an unfortunate accident in July, when a belly landing was made following fuel starvation of both engines caused by fuel system mishandling by a trainee pilot. The aircraft was subsequently repaired. This was the second accident to a Canberra; the first had involved the B.1 prototype, VN850, which crashed near Hucknall on 13 June, and was completely destroyed. The aircraft was being used by Rolls-Royce for Avon development work, and the Rolls-Royce test pilot died in the crash. A few days before, VN850 had flown powered by the developed Avon

The old and new at Warton in January 1951. The crew of a No.101 Squadron Avro Lincoln are seen with a line-up of Canberras, which were to replace the squadron's Lincolns a few months later. The Canberras are B.1 VN828 (nearest the Lincoln), and WD930, WD929 and WD931, the first three production B.2s. (*British Aerospace*)

RA.7 engine, which was intended for later versions of the Canberra.

During 1951 preparatory work was started for the manufacture of Canberras at the Government Aircraft Factory at Fisherman's Bend, Melbourne, Australia. The version to be built in Australia was designated Canberra B.20, and was similar to the British B.2 except for the addition of integral fuel tanks in the wings. Assemblies for the forty-eight B.20 aircraft ordered were built at Fisherman's Bend, but final assembly and flight



The second Canberra B.2 to be supplied to Australia, A84–125, previously WD983. (*British Aerospace*)

testing were done at Avalon Airfield. Preparations also started in 1951 at the Commonwealth Aircraft Corporation factory for the manufacture of Avon engines to be installed in the GAF-built Canberras. Two English Electric-built B.2 aircraft were bought by Australia as pattern aircraft; these were WD939 and WD983, which received the Australian serial numbers A84-307 and A84-125 respectively. They were diverted from the first British contract, and were replaced by two extra aircraft, WP514 and WP515. The first aircraft to go to Australia was A84-307, which was flown out by an Australian crew in August 1951. This flight was the first from England to Australia by a jet aircraft, and was made in six stages over a period of four days. Flying time for the 10,240 miles from Lyneham, Wiltshire, to Darwin, Northern Territory, was about 21½ hours. However, although a number of records were broken during the flight, no official records were established because the flight was not officially observed. The second aircraft, A84-125, went to Australia in 1952, and two more, WD935 and WD942, were also supplied on loan.

The transatlantic flight by WD932 in February 1951 had clearly shown that the Canberra was capable of substantially improving on the existing record time for the ocean crossing. Accordingly, when WD940 came to make the flight in August 1951, English Electric decided that the flight should be timed by FAI observers so that an official record could be established. On 31 August, WD940 flew from Aldergrove to Gander at an average speed of 481.12 mph in a flying time of 4 hr 18 min, and in doing so set a new record time which was more than two hours less than the previous record for the east to west crossing. The crew for the flight were R.P. Beamont, pilot; D.A. Watson, navigator; and R.H.T. Rylands, radio operator. This record was the first of 18 point-to-point records to be established by the Canberra, and attracted considerable publicity. In the United States, WD940 was handed over to the Martin Company and was used to flight-test features proposed for the B-57 which were not standard on the Canberra.

The second RAF unit to receive Canberras was 231 Operational Conversion Unit, which was formed at Bassingbourn, Hertfordshire, in

December 1951. Although the first Canberra squadron had specially-chosen aircrews, later units were to have the normal squadron crews. Many of these had relatively little experience, and included numerous National Servicemen. The number of Canberra squadrons which were to be formed, coupled with the advanced character of the aircraft, necessitated the formation of a specialist conversion unit for crew training. No.231 OCU was to fulfil this role at Bassingbourn for almost 20 years.

The year 1951 ended tragically when on 21 December, WD932, which had been handed over to the Martin Company in March, crashed on a flight from the Martin works at Baltimore. Both the pilot and navigator ejected, but the navigator's parachute failed to open properly and he was killed. An urgent investigation followed the crash since there was some indication that the aircraft might have suffered a structural failure below maximum design loading. Such a failure should not have occurred under the flight conditions which the aircraft was supposed to have experienced. The most conclusive way to test the integrity of the structure was to fly another Canberra under the same conditions. Therefore, early in February 1952, Beamont had the unenviable task of making a flight in WD958 to repeat the manoeuvres made by WD932 during its last flight. No trouble was experienced on this flight, thus verifying that the aircraft was structurally safe. Eventually, the investigation determined that during the last flight of WD932 incorrect scheduling of fuel usage had resulted in the balance of the aircraft becoming excessively tail heavy. On entering a tight turn the aircraft had become unstable, causing the wings to be over-stressed. This condition resulted in a failure of the port wing near to the engine nacelle. The accident had not therefore been due to a design fault.

Although 1952 was essentially a year of consolidation, it was not without highlights. With the steady expansion of production, deliveries to Bomber Command squadrons increased considerably. Production of B.2 aircraft by English Electric, which was about five a month at the end of 1951, had doubled by May 1952. A factor which helped to increase Canberra output was the ending of Vampire production in February, so that the full resources of the factory at Preston and the aerodrome at Samlesbury could be devoted to Canberra work. In addition, the factory at Accrington, which English Electric had taken over in 1951, began to manufacture Canberra parts in 1952. In January 1952, the fortieth production aircraft, WD980, was completed at Samlesbury. All previous production flight-testing had been conducted at Warton, but WD980 was flight-tested at Samlesbury, as were all subsequent production aircraft.

The first Canberra unit, 101 Squadron at Binbrook, held an open day for the Press early in January 1952, to celebrate reaching operational status. A few days later, 617 Squadron, also at Binbrook, received its first aircraft, WD961. The third squadron to re-equip, again at Binbrook, was No.12, which received its first aircraft, WD987, in late March. The Binbrook wing of five squadrons was completed by 9 Squadron and 50 Squadron, which started to receive their aircraft in May and August respectively. A second Canberra wing started to form at Hemswell in August, 109 Squadron being the first in the wing. Deliveries to 231 OCU continued during the year, the unit having over 20 Canberras by the end of December.

On 25 March, 1952, English Electric suffered a serious blow, when a new

The Canberra T.4 prototype WN467. Finish was silver overall with yellow bands round the outer wings and rear fuselage. (*British Aerospace*)

aircraft crashed on its first flight. The pilot, T.B.O. Evans was killed. The aircraft, WD991, went into a steep dive a few minutes after taking off from Samlesbury, and crashed just to the west of Preston. This accident was only the second since the company had restarted aircraft work in 1938, and Evans was the first company pilot to be killed. Although several Canberras were lost by various operators in the first few years of flying, the accident rate was remarkably low for a new high-performance aircraft entering service.

Three events in the summer of 1952 marked further steps in the development of the Canberra. On 12 June, the prototype T.4, WN467, ordered early in 1951, made its first flight. The T.4 was basically similar to the B.2 bomber, but changes were made to the front fuselage to suit the aircraft's role. The pupil pilot and his instructor were seated side-by-side, with the navigator at the rear of the cabin. As no bomb-aimer was to be carried, there was no glazed nose, this being replaced by a fairing of similar shape, the T.4 not being intended for bombing training. The second of the three events took place on 31 July, when the first production PR.3 photographic-reconnaissance aircraft made its initial flight. The aircraft, WE135, was retained by English Electric for development work until 1954. Further PR.3 aircraft came off the production line at a rate of about one a month in 1952.

The third notable event in mid-1952 was the first flight of the Avon RA.7-powered prototype B.5, VX185. This aircraft previously had had RA.3 engines. The Avon RA.7 provided 7,500 lb of thrust, 1,000 lb more than produced by the RA.3. VX185 first flew with RA.7 engines on 15 July, and this flight marked the advent of a second generation of Canberra variants. VX185 had featured integral fuel tanks in the wings when built as the B.5 prototype, and the integral tanks and RA.7 engines were to be the most important new features of the next two new variants of the Canberra. The application of these features to the basic B.2 and PR.3 aircraft was to produce the B.6 and PR.7 respectively, and VX185 became in many respects a prototype for both versions.

Six weeks after first flying with RA.7 engines, the capabilities of VX185 were demonstrated in a spectacular manner. On 26 August, this aircraft made the first ever out and back crossing of the North Atlantic in one day. Piloted by Beamont, the westbound flight from Aldergrove to Gander was

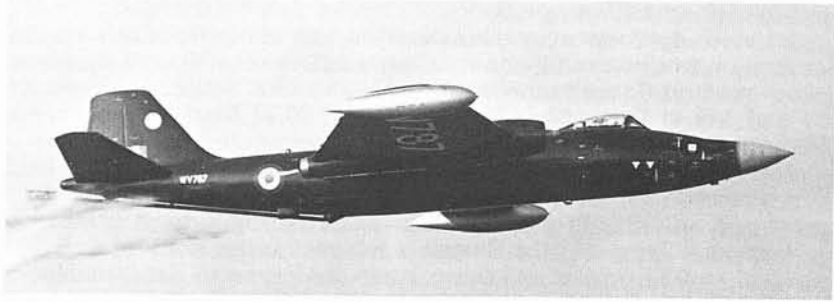
made in 4 hr 33 min. Peter Hillwood was the second pilot and the navigator was D.A. Watson. After a turn-round lasting just over 2 hours, the return flight was made in 3 hr 25 min, Hillwood piloting the aircraft. The west to east flight was an official point-to-point record, as was the complete return flight, for which the total time was 10 hr 3½ min. Wingtip fuel tanks had not been fitted, although an auxiliary tank was carried in the bomb-bay. The flights were given extensive publicity in Britain and abroad, and the crew received numerous congratulatory messages, including one from HM Queen Elizabeth II.

Before this event, the B.2 WD962 had established a new official record between London and Tripoli in Libya on 18 February, 1952. In Libya, WD962 was used for ejector-seat trials. Later in the year, on 28 September, WD987 of 12 Squadron set a new record of 9 hr 55 min between London and Nairobi, including a refuelling stop in Egypt.

In October 1952, a large-scale exercise was held to test the air defences of the United Kingdom. For the first time Canberras played an important part in such an exercise, and aircraft from the newly formed Canberra wing at Binbrook flew many sorties. Canberras, together with Avro Lincolns and Boeing B-29 Washingtons, simulated attacking enemy raiders, which the North American Sabres, Gloster Meteors and de Havilland Venoms of Fighter Command attempted to intercept. At their normal operating height of about 45,000 ft the Canberras proved virtually impossible to catch, and for most of their sorties they were limited to a maximum altitude of 35,000 ft in order to give the fighters some chance of obtaining interception practice. However, even with the Canberras operating at reduced altitude the fighters were not particularly successful. The Canberra, which had no defensive armament, relied on speed and manoeuvrability to avoid being 'shot down'.

Canberras were well represented at the 1952 Farnborough air show, five aircraft taking part. English Electric demonstrated the development aircraft, VX185, and the trainer prototype, WN467. Three engine manufacturers each exhibited a Canberra engine test-bed, these being WD932 with Bristol Olympus engines, WD933 with Armstrong Siddeley Sapphire engines, and WD943 with Rolls-Royce Avons fitted with reheat. A few weeks later, in October, another form of exhibition of the Canberra took place. Four aircraft of 12 Squadron left Binbrook on 20 October for a 24,000 miles tour of South America, known as *Operation Round Trip*. The aircraft, WD987, WD990, WD993 and WD996, visited 14 countries in South and Central America, attracting great interest and much publicity. Intended primarily as a goodwill mission, the tour also presented opportunities to show off the Canberra to numerous potential export customers. Over 30 flying displays were given, watched by several hundred thousand spectators, most of whom had never seen a jet aircraft before. The four aircraft returned home after six and a half weeks, and the first Canberra overseas tour was judged to have been a great success.

English Electric completed 99 Canberras during 1952, against 44 the previous year. All of the 99 aircraft were B.2s except for four PR.3s and one T.4 prototype. Late in 1952, the first sub-contract aircraft were finished, promising greatly increased output in 1953 from four production centres in the United Kingdom. The first Short-built aircraft, WH853, made a 30 minute initial flight from Sydenham (Belfast Harbour Airport)



Built as a Canberra B.2, WV787 was a good example of a development aircraft. Initially used as a test-bed for reheat Armstrong Siddeley Sapphire engines, the aircraft was later fitted with a Mk 8 front fuselage and nose radome for use as a radar test-bed. The photograph shows WV787 in its third role, that of water-spray tanker for engine icing tests. The aircraft with the test engine flew behind WV787 in an artificial cloud. (*MAP*)

on 30 October, 1952. This flight was made two years and seven days after work had started on Canberra manufacture, and was in accordance with the time schedule then laid down. The first Avro-built Canberra, WJ971, first flew from Woodford, near Manchester, on 25 November. The 45 minute flight was made two years and fourteen days after the start of Canberra work, and was on schedule. Handley Page's first Canberra, WJ564, made a successful initial flight from the company's Radlett aerodrome on 5 January, 1953, again just over two years after the start of work. Regular deliveries from all manufacturers started early in 1953, two or three aircraft a month being the average production rate from each factory.

The widespread overseas interest in the Canberra did not result in any direct export sales until January 1953. Venezuela was the first export customer, ordering six B.2s. Work had started late in 1952 in anticipation of the contract, and in order to permit early deliveries, the six aircraft were diverted from MoS contracts. Because of all the English Electric pilots being fully occupied flight testing Canberras, the first two Venezuelan aircraft were delivered by RAF crews. These aircraft, 1A-39 and 2A-39, left Warton on 20 March, 1953, and were routed via Gibraltar. The next two, 3A-39 and 1B-39, left Warton on 9 May, flown by crews from Silver City Airways, and routed via Gander, Baltimore and Jamaica. One of the Silver City crews was J.W. Hackett, pilot, and P.J. Moneypenny, navigator, who were to make numerous Canberra delivery flights in the future. These included the last two Venezuelan B.2s, 2B-39 and 3B-39, which left Warton on 5 June and 14 July respectively. The delivery of 3B-39 was completed in one day, the aircraft being flown via Gander and Baltimore to Venezuela in 12¼ flying hours.

During 1953 steady output by English Electric, and the start of deliveries from the three sub-contractors, enabled 15 new RAF Canberra squadrons to be formed. Two of these squadrons received PR.3 aircraft, 540 Squadron at Wyton being the first to take delivery. The second PR.3 unit was 82 Squadron, also at Wyton, which exchanged the last Lancasters in Bomber Command for new Canberras. All of the other squadrons received

B.2 aircraft, and all except No.192 Squadron were bomber units. No.192, based at Watton, was a Signals Command unit which used Canberras for calibration work on radio and radar installations. The bomber squadrons which received Canberras were 10, 18, 21 and 27 at Scampton, 15, 40, 44, 57 and 149 at Coningsby, 76 at Wittering, 90 at Marham, and 139 at Hemswell.

A further eight records were obtained with the Canberra during 1953. The first two of these records were set up in January by the PR.3 prototype, VX181, in the course of a ferry flight to Australia for experimental flying over the Woomera weapons range. Routing via Egypt, Karachi and Singapore, and flown by an RAF crew, VX181 established new London-to-Karachi and England-to-Australia record times. The aim had been to fly from London to Darwin, Australia, in under 24 hours; in fact a time of almost exactly 22 hours was achieved. This was less than half the previous record time, and the average speed for the 8,608 miles was 391 mph.

By the summer of 1953 both of the manufacturers building Canberras under licence had completed their first aircraft. The Australian Government Aircraft Factory flew its first Canberra B.20, A84-201, for the first time on 29 May at Avalon, and a few weeks later the aircraft was delivered to the RAAF for Service trials. In America, the first Martin-built B-57, 52-1418, made its initial flight on 20 July, and it was followed by a steady flow of aircraft from the production line to satisfy large orders.

In Britain, the next Canberra developments were the B.6 and PR.7 versions. Since the most important new features of these variants had been tested on VX185, prototypes were not considered necessary. The PR.7 preceded the B.6 by some months, the first PR.7, WH773, making its initial flight on 16 August, 1953, piloted by Beamont. The most significant operational advantage of the PR.7 over the PR.3 was an increase in the former's maximum range. To achieve this, extra fuel was carried in integral tanks located in the wing leading-edges. The extra fuel, and other changes, resulted in an increase in maximum weight and led to the fitting of the uprated RA.7 engine to maintain performance, and a stronger under-carriage with larger wheels and anti-skid brakes. WH773 was handed over to 540 Squadron in September, joining the special flight of that Squadron which had been formed to enter Canberras in the forthcoming London to New Zealand air race.

The first production T.4 trainer, WE188, was completed five weeks after the first PR.7, making its initial flight on 20 September. After that date, four different marks of Canberra were being delivered from Samlesbury. The month of October illustrated the variety of output, for five B.2s, nine PR.3s, one T.4 and one PR.7 were completed. Incidentally, the total of 16 aircraft built in this month was the highest monthly figure achieved by English Electric during Canberra production.

March 1953 saw the Canberra achieving publicity for flights of a different kind. In trials with WD952, the Bristol Olympus engine test-bed, the world altitude record for aeroplanes was exceeded several times, although no attempts were made to establish a new official record. However, on 4 May a new official altitude record of 63,668 ft was achieved. (This was 7.1 per cent higher than the previous record, which had been held by an English Electric-built Vampire). The pilot of the

Canberra was W.F. Gibb of the Bristol Aeroplane Company, and the flight was made from the company's Filton aerodrome. The normal thrust rating of the Olympus BO1.99 engine was 9,750 lb, but the examples installed in WD952 were limited to 8,000 lb thrust because of space limitations.

Following the Coronation of HM Queen Elizabeth II on 2 June, 1953, four RAF Canberras were involved in *Operation Pony Express*, which was a series of high-speed transatlantic courier flights made to carry films of the ceremony to Canada. As a result of these flights, the films were televised in Canada and the USA less than eight hours after leaving London. About six weeks after the Coronation, the Royal Review of the RAF took place. Among the 950 aircraft displayed were 54 Canberras, 48 of which took part in the formation fly-past.

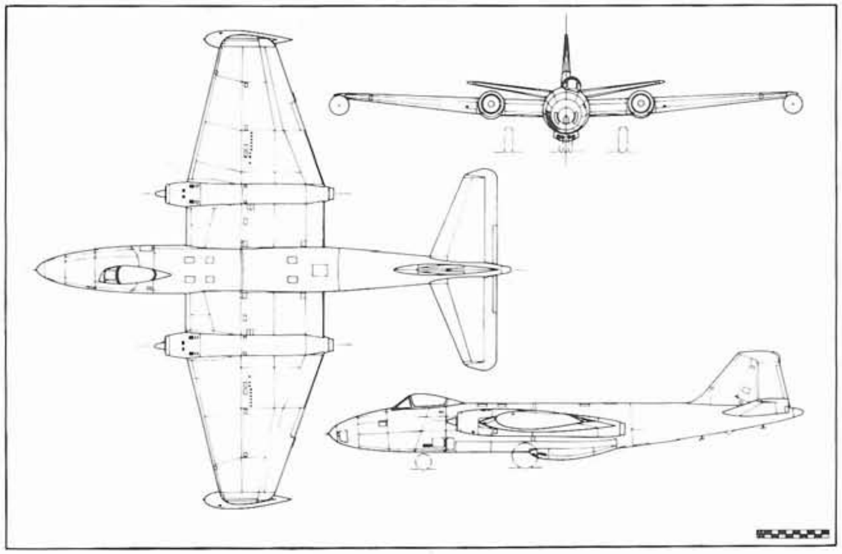
The fifth production Canberra PR.3, WE139, which won the London—New Zealand Air Race in 1953. This achievement was marked by the inscription on the nose, and by the race number 3 on the rear fuselage. Colour scheme was light blue upper surfaces with light grey lower surfaces, standard for production PR.3s. (*British Aerospace*)

The England to New Zealand air race was held in October 1953, the entrants being divided into speed and transport sections. Five Canberras were entered in the speed section, as were several other types. However, for various reasons all the other types withdrew before the race, so that the Canberras were the only competitors in the speed section. Three of the Canberras were entered by the RAF, and were operated by a special flight of 540 Squadron. The aircraft concerned were the first PR.7, WH773, and two PR.3s, WE139 and WE142. The RAAF entered the remaining two Canberras, which were A84-201 and A84-202, the first two Australian-built B.20s. Leaving London on 8 October, all the Canberras reached Christchurch, New Zealand, in flying times which were within 15 minutes of each other. Their placing in the race, therefore, depended largely on the length of time spent on the ground at en route refuelling stops. The RAF-entered PR.3, WE139, was judged the winner, covering the 11,792 miles in a total time of 23 hr 50 min at an average speed of 494.5 mph. Only 82 minutes was spent on the ground in the course of four refuelling stops. In the course of winning, WE139 established two new point-to-point records, these being London to Basra, Iraq, and London to Christchurch. The PR.7, WH773, also set a new record, between London and Colombo, Ceylon (now Sri Lanka).

Early in 1953, the RAF Flying College at Manby, Lincolnshire, took delivery of WH699, a standard B.2 aircraft. Named *Aries IV*, WH699 was

used for specialised training, in the course of which a number of record and notable flights were made in the period 1953 to 1959. The first of these took place in December 1953, when a return flight to South Africa was made. During this flight new record times between London and Capetown, and Capetown and London, were established. At the end of 1953 the Canberra held 12 point-to-point records and the world altitude record for aeroplanes. As a result the aircraft was world famous.

Following the end of the Korean War in July 1953, international political tension slowly lessened. In Britain the rate of expansion of the armed forces was allowed to slacken, and over a three-year period many hundreds of aircraft of nine different types were cancelled. Included among these types was the Canberra B.2, about 250 being cancelled. The orders which had been placed with Handley Page and Avro were halved, 75 of the 150 aircraft ordered from each company being cancelled. Short Bros & Harland was more fortunate, as only 41 of its order for 150 aircraft were cancelled. Sixty of the remaining aircraft were to be built as B.2s and the rest as B.6s. About sixty B.2s ordered from English Electric were cancelled, and contracts for about 100 more were changed to call for B.6 and B(I)8 aircraft.



English Electric Canberra B(I)8.

In the early days of Canberra flight-testing, the pilots employed by English Electric were R.P. Beamont, T.B.O. Evans, P. Hillwood and J.W.C. Squier. With the establishment of production, extra pilots were required, as development flight-testing continued to occupy several pilots for a number of years. D.M. Knight, P.G. Lawrence, J.W. Still and L.M. Whittington joined the company in the early 1950s, and were mainly concerned with production test flying. Other pilots employed in later years who took part in Canberra test flying were T.M.S. Ferguson, J.W.

Hackett, J.C. Hall, J.K. Isherwood and D. de Villiers. The range of speeds and heights at which production Canberras had to be flown was particularly wide, and large areas of clear sky and good weather were required for routine flight-testing. Most test flying was done over the Irish Sea to the west of Warton. However, if the weather there was unsuitable, areas over the North Sea and English Channel were used. The high cruising speed of the Canberra enabled these relatively remote regions to be reached in about half an hour. Four pilots were normally engaged in production flight-test work, each making up to four flights a day. Most aircraft were cleared in about five flights, which usually totalled about four flying hours. However, sometimes ten or more flights were necessary, particularly for aircraft fitted with special equipment.

The year 1954 opened with the initial flight of the first B.6, WJ754, on 26 January. This aircraft was the first production B.6, there being no prototype. Based on the B.2, the B.6 incorporated the new features introduced by the PR.7, the most important of which were the Avon RA.7 engines and the integral wing fuel tanks. Production of B.6 aircraft was three or four a month, and by June enough had been delivered for 101 Squadron at Binbrook to be re-equipped. No.109 Squadron was re-equipped later in the year and Nos.9, 12, 76, 139 and 617 Squadrons were similarly re-equipped during 1955. These seven were the only Bomber Command units to operate the B.6.

Eleven other squadrons received their first Canberras in 1954, eight of these being bomber units which received B.2s, the other three being reconnaissance squadrons which received PR.3 and PR.7 aircraft. These squadrons were Nos.35, 115 and 207 based at Marham, 61 and 100 at Wittering, and 199 at Honington, these units exchanging their Lincolns and Washingtons for B.2s. An existing Canberra squadron, No.149, moved to Germany in August 1954, and was based at Gütersloh. The unit was the first of four squadrons which were to form a Canberra B.2 wing as part of the 2nd Tactical Air Force. Two more of these squadrons, Nos.102 and 103 were formed at Gütersloh late in 1954, and the fourth in 1955. However, the first Canberra squadron permanently based outside the United Kingdom was 69 Squadron, which in May 1954 exchanged their de Havilland Mosquitos for PR.3s at Laarbruch, in Germany. The other two squadrons to receive PR Canberras in 1954 were Nos.58 and 542, both based in the United Kingdom. These squadrons re-equipped with the PR.7 version, since production of the PR.3 had been completed in January 1954. By the end of 1954, thirty-two RAF squadrons were equipped with Canberras, 26 of these operating in the bomber role. The demand for Canberra aircrews imposed a heavy burden on 231 OCU, and this unit received the first T.4 to be delivered, in the spring of 1954. Canberra bomber squadrons each received at least one T.4, which was used for check flying and continuation training.

The second Canberra export contract was received by English Electric early in 1954, when France ordered six B.6s. These aircraft were to be used as test-beds for engines and as carriers for missiles during development trails. In order to enable quick deliveries to be made, the first three French aircraft were diverted from the British B.6 contract. Thus WJ763, the tenth British B.6, became F763 which first flew in April and was delivered in August. The next two aircraft diverted were WJ779 and WJ784, which

The second of the six Canberra B.6s supplied to Ecuador, seen at Warton before delivery in 1955. (*British Aerospace*)

Originally built as the Canberra B.5 prototype, VX185 is seen here after conversion to become the B(I)8 prototype. Notable are the new design of cockpit canopy, and the remarkably high-gloss black overall finish. (*British Aerospace*)

became F779 and F784, and were delivered at the end of 1954. The remaining three French aircraft took their turn on the production line and were completed in 1955. Soon after the French contract, a third export order was received, again calling for six B.6 aircraft, this time from Ecuador. The Ecuadorian aircraft were ordered in May 1954 but deliveries did not take place until mid-1955.

The first seven marks of Canberra had resulted in production of aircraft for three basic operational roles. In July 1954 the Mk 8 Canberra appeared, and introduced a fourth. Based on the B.6 light tactical bomber, the B(I)8 was designed for the interdictor role. The interdictor was intended for low-level attacks behind enemy lines, mainly at night, and particularly on targets connected with communications. For these attacks bombs, rockets and cannon were to be used. The English Electric development aircraft VX185, originally built as the prototype B.5, was modified during 1954 to become the B(I)8 prototype. Beamont piloted the

aircraft on its first flight on 23 July from Samlesbury. It made its public début at the Farnborough air show in September.

The immediately obvious new feature of the B(I)8 was the front fuselage, which was extensively redesigned, although the overall fuselage length was unchanged from the B.6. The crew of the B(I)8 was reduced to pilot and navigator, the duties of the bomb-aimer being performed by the navigator. As in other Canberras, the pilot's ejection-seat was offset to the port side of the aircraft but in the B(I)8, however, the pilot was seated under an entirely new design of fighter-type canopy. This canopy did not open and, as in other Canberras, crew entry was by way of a hatch in the starboard side of the nose. The navigator's seat and plotting table, behind the pilot in earlier Canberras, were moved forward into the nose of the B(I)8 and turned round so that the navigator was seated with his back to the wall of the cabin. A prone position in the glazed nose was provided for him when he was acting as bomb-aimer, and he also had a second seat near the entry hatch for use during take-off and landing. Most of the equipment in the B(I)8 was similar to that of the B.6, and the engine installations were the same. There was no significant difference in performance between the B(I)8 and B.6.

The only other new features introduced concerned the aircraft's armament. Provision was made for a detachable under-wing pylon located outboard of the engine. Each of these pylons could be used to carry either one 1,000 lb bomb, or a pod containing 37 air-to-ground rockets. In addition, the bomb-bay was modified to carry a gun pack containing four 20 mm Hispano cannon. Designed by Boulton Paul Aircraft, the pack was mounted in the rear of the bomb-bay, and was intended for use against ground targets. The supply of ammunition carried in the pack was a

The first Canberra B(I)6, WT307, seen with a bomb attached to each underwing pylon, and a gun pack fitted in the bomb-bay. (*British Aerospace*)

generous 525 rounds per gun. The forward part of the bomb-bay could hold either three 1,000 lb bombs or 16 flares for use in night attacks. However, the gun pack and other fittings in the bomb-bay could be quickly removed to enable the normal tactical bombing load to be carried.

A number of B.6 aircraft were modified during the assembly to be able to perform the interdictor role, being redesignated B(I)6 and known as interim interdictors. These aircraft were fitted with the under-wing pylons and bomb-bay gun pack of the B(I)8, but otherwise were similar to the standard B.6. A total of twenty-two B.6s ordered under the third English Electric contract were completed as B(I)6 interim interdictors, and the requirements for a futher 30 aircraft in this contract were changed to call for B(I)8s.

During 1954, English Electric received its fourth British Canberra production contract. As a result of the planned reductions in RAF strength, only 57 aircraft were ordered under this contract, 25 of which were to be B(I)8s, with the remaining 32 being a new version, the PR.9. Intended for high-altitude photographic reconnaissance, and initially designated HA PR.9 to indicate this fact, the PR.9 was to incorporate a number of significant new features. In order to be able to evaluate some of these a prototype was ordered, to be obtained by modifying a PR.7. Accordingly, in May 1954, the PR.7 WH793 was delivered direct from the production line at Samlesbury to D. Napier & Son at Luton for modification. Later in 1954, English Electric received a further contract, for four B.6s and two T.4s, this being the fifth British contract.

Although no new records were set during 1954, Canberras did make a number of notable flights. In February, WH699 *Aries IV* of the RAF Flying College made the first flights by a British jet aircraft in the Arctic, during the course of a visit to the far north of Canada. The following October the same aircraft made the first flight over the North Pole by a British jet aircraft, the flight being made from northern Norway. In June, eighteen RAF Canberras flew north to visit Sweden and at the same time six aircraft of 27 Squadron went south to make a goodwill tour of eight Mediterranean countries. Towards the end of the year, 57 Squadron sent six Canberras on a tour of Iraq, Jordan, Libya, Tunisia and Cyprus. As well as being effective goodwill gestures on behalf of Britain and the RAF, these overseas tours were also valuable training experience for the aircrews.

The first unit to use the Canberra in anger was 101 Squadron, in February 1955. Between 1948 and 1960 British forces were engaged in operations against communist guerillas in Malaya, who were attempting to take over the country. The RAF took part in these operations, at first using Lincolns and then from early 1955, UK-based Canberra squadrons were temporarily detached to Singapore to supplement and eventually replace the Lincolns. No.101 Squadron was the first of these, later being followed by 617, 12 and 9 Squadrons. The practice of detaching UK-based Canberras to Malaya ceased in 1957 when Canberras were permanently based in Singapore.

During 1955, RAF squadrons flying the Canberra increased by three. The newly equipped units were all based in Germany. First to form was 104 Squadron, the last of the Gütersloh wing of four B.2 squadrons. The other two new units were both based at Laarbruch and flew PR aircraft; 31

Squadron formed in March with PR.3s, and 80 Squadron received PR.7s in June. The RAF then had twenty-three bomber, three PR and one special duties squadron in the United Kingdom, and four bomber and three PR squadrons in Germany.

With the approaching replacement of the Canberra in the straightforward bomber role by Vickers-Armstrongs Valiants, Avro Vulcans and Handley Page Victors, production of Canberra bomber variants ceased, and the B(I)6 and B(I)8 interdictors started to come off the Samlesbury assembly line. The first B(I)6, WT307, made its initial flight on 31 March, 1955, and nine weeks later WT326, the first B(I)8, flew for the first time on 8 June. Both aircraft went to the A & AEE at Boscombe Down for Service trials after a period of flight-testing at Warton. A futher milestone in the development history of the Canberra was reached on 8 July, when the prototype PR.9, WH793, made its first flight at Luton, piloted by Napier test pilot, M. Randrup. Although English Electric had done the basic design work for the PR.9 version, detail design and modifications for the prototype had been done by Napiers at Luton.

The PR.9 was generally based on the PR.7, although later model Avon engines were fitted, the wing planform was modified, and the front fuselage was similar to that of the B(I)8. In addition, there were numerous other changes in the equipment and systems of the aircraft. However, WH793 was intended for use mainly as an aerodynamic prototype, and was not, therefore, to the full PR.9 design standard. In particular, WH793 retained its original PR.7 front fuselage but did have the Avon RA.24 engines, modified wing and power-operated flying controls of the PR.9. During test flying of WH793 in 1955 and 1956, some aerodynamic

The Canberra PR.9 assembly line at Short Brothers & Harland at Belfast. The fifth aircraft, XH133, is at the head of the line. The hinged nose permits access to the navigator's compartment, the roof panel of which has not yet been fitted. The pilot's ejector seat and canopy are on trestles alongside the nose. (*Short Brothers & Harland*)

problems were encountered. The solution of these involved increasing the wing span by 19 in and fitting turbulence generators on the wings and tailplane. Development work continued until the first production PR.9 was completed in mid-1958.

Many of the numerous research programmes undertaken by Canberras were concerned with radar equipment. Most of the aircraft used for this work were fitted with lengthened noses which had large radomes of various shapes. The first Canberra to be so modified (by Boulton Paul Aircraft in 1955) was the third prototype B.1, VN828, which was used at the Telecommunications Research Establishment at Defford from mid-1955 onwards. Many of the aircraft similarly modified in later years were used for the development of airborne interception radars. In 1955, a proposal was made to develop an all-weather fighter version of the Canberra. This version was to have had AI radar in a modified nose similar to that of VN828 and the gun pack as fitted to the interdictor aircraft. However, by 1955 all-weather fighters of superior performance to that of the Canberra, such as the Gloster Javelin, were nearing entry into service, and the fighter Canberra project was shelved.

Canberra manufacture at Preston continued at a high rate during 1955, with production in later years assured by contracts for interdictor and PR.9 aircraft, and by outstanding orders for T.4s and PR.7s. At Belfast, Shorts had orders for B.6 aircraft only, manufacture of which would be completed in 1956. To ensure continuity of production at Belfast after 1956, twelve of the B(I)8s ordered from English Electric were sub-contracted to Shorts in April 1955. Shorts was to build the whole of these aircraft except for the front fuselages and other parts peculiar to the B(I)8, which English Electric was to supply. The situation at the other two sub-contractors, Avro and Handley Page, was different, as both companies ceased Canberra manufacture during 1955. The last of the seventy-five B.2s built by Avro, WK165, was completed in March 1955, and WJ682, the last Handley Page-built B.2, was delivered in May.

Overseas use of the Canberra expanded considerably during 1955. The six B.6s ordered by Ecuador in 1954 and the remaining three aircraft of the French order were delivered in 1955. All six French aircraft were used for many years for experimental work, in particular at the Centre d'Essais en Vol, at Bretigny. In Australia, the first Canberra squadrons were formed during 1955, Nos.2 and 6 Squadrons at Amberley exchanging their Lincolns for Australian-built B.20s. The United States Air Force stationed Martin B-57s in Europe during 1955, and in October two of these aircraft visited Warton. The English Electric design team were, therefore, able to see for themselves what changes Martin had made to the Canberra to suit it for USAF use.

Canberras of the RAF continued to make overseas visits during 1955. In February twenty aircraft from Nos.21 and 27 Squadrons went to Cyprus for an exercise, and several of the aircraft made goodwill visits to Egypt, Aden and Kenya. A detachment of Canberras from 139 Squadron toured Canada and the West Indies in the following summer. The RAF Flying College Canberra, *Aries IV*, which had first made flights in the Arctic in 1954, made a further notable flight in the area in June 1955, when it was flown from Bardufoss in Norway, over the North Pole to Fairbanks, Alaska. A further distinction was gained during the return flight to the

United Kingdom, a new Ottawa-to-London point-to-point record time being set. However, in August the achievements of *Aries IV* were overshadowed by those of two other Canberras.

On 23 August, 1955, English Electric used a new PR.7 aircraft, WT528, to set up three speed records. Flown by Hackett and Moneypenny of Silver City Airways, the aircraft made an out and return crossing of the Atlantic. Three years previously, a Canberra had made the first such crossing, flying between Aldergrove and Gander. The total distance then covered was nearly 4,150 miles, but the record flights made by WT528 totalled 6,915 miles, being made between London and New York. WT528 took a total time of 14 hr 22 min for the return flight, including a 35 minute refuelling stop in New York. The three new point-to-point speed records established were London-New York, New York-London and the round trip London-New York-London, the average speed for the return flight being 481.25 mph. These record flights received a great deal of publicity and increased the number of point-to-point speed records held by the Canberra to sixteen.

Six days after the record flights by WT528, the Olympus-engined test-bed WD952, established a new world altitude record. The previous record had been set by the same aircraft two years earlier, but on 29 August WD952 broke this by over 2,200 ft, reaching 65,889 ft. Some time after setting up the first altitude record, WD952 had been fitted with the more powerful Olympus B.O1.101 engine, and it was the extra thrust of these engines which enabled the new record to be established. As on the first occasion, W.F. Gibb was the pilot, and the flight was again made from Filton.

During 1955, English Electric received three contracts for Canberras. The first of these was for eleven PR.9s, and brought the total number of aircraft of this mark on order to 43. Another British contract followed, but this was for three aircraft only, two T.4s and one B.6. The third and most significant contract was for eight B(I)8s, placed by Peru in November. Canberra production started to decline during that year. However, the number of marks in production had increased to five, these being the T.4, B.6, B(I)6, PR.7 and B(I)8. By the end of 1955, Shorts had produced over 100 aircraft, the one hundredth, WH984, having been completed in October.

The reduction of the Bomber Command Canberra force started in 1956. The disbanding and reforming of squadrons in that year left the RAF with thirty operational Canberra squadrons, of which eight were based outside the United Kingdom. Among the units which were reformed were two interdictor squadrons and one reconnaissance squadron, based in Germany; No.213 received B(I)6s in March at Ahlhorn, No.88 was formed with B(I)8s at Wildenrath in May, and No.17 Squadron was equipped with PR.3s at Wahn in June. The first Canberra squadron in the RAF's Middle East Air Force was formed in May, when 13 Squadron based at Akrotiri, Cyprus, received PR.7 aircraft.

Although the Canberra began to be superseded in the bomber role in 1956, the use of the aircraft for research, development and experimental purposes continued to expand. In February, WT329, the fourth production B(I)8 went to Aden for tropical trials, and the opportunity was taken en route to set a new London-to-Cairo record time. The PR.7

WT528, which in 1955 had made the Atlantic crossings to New York and back, was handed over in June 1956 to the RAF Flying College at Manby. Named *Aries V*, this aircraft made numerous long-range navigational training flights to many parts of the world, supplementing the College's earlier Canberra, *Aries IV*.

The Canberra had already proved to be a versatile flying test-bed for jet engines, and during 1956 this versatility was further demonstrated when two Canberras entered service as test-beds for rocket engines. First to appear was WK163, a standard B.2, which was modified by Napiers to carry a Napier Double Scorpion twin-chamber rocket engine in the bomb-bay. The first airborne firing of this engine was made on 20 May. The second type of rocket engine to be tested in a Canberra was the de Havilland Spectre, which was the first British rocket with fully variable-thrust to be air tested. During 1956, Follands fitted a Spectre engine to the prototype Canberra VN813, and on 18 December the first airborne firing was made. The capacious bomb-bay of the Canberra enabled the rocket engines and their oxidant tanks to be conveniently mounted, and the good high-altitude performance of the aircraft permitted flight-testing in the thin air conditions for which the rockets were designed.

During 1956, the high-altitude performance of the Canberra was used for a series of flights made in support of British atomic weapon tests conducted at Maralinga in Australia. A special flight of six B.6s was formed as part of the task force conducting the tests, the aircraft being operated by 76 Squadron. The Canberras made flights in and around the mushroom clouds formed after the explosions, collecting dust samples by means of special air filters fitted inside modified wingtip tanks. At least one of the aircraft was fitted with a Double Scorpion rocket engine, which enabled samplng flights to be made above the normal ceiling of the Canberra. The Maralinga tests were followed by hydrogen bomb tests at Christmas Island in the Pacific Ocean, during which four Canberra PR.7s operated by 100 Squadron were used to make sampling flights.

The only major war operation in which RAF Canberras were engaged was the Anglo-French invasion of the Suez Canal Zone in Egypt late in 1956. During September and October the steady deterioration of political relations with Egypt caused both Britain and France to assemble powerful military forces in the eastern Mediterranean. The British forces included a large RAF contingent which was over 30 squadrons strong. Seventeen of these were bomber squadrons, and except for four squadrons of Valiants, all were Canberras. Normally based in the United Kingdom, these squadrons moved to bases in Malta and Cyprus, from where operations began on the night of 31 October. The primary object of the bomber squadrons was to put the Egyptian Air Force out of action, and accordingly the first raid was made on airfields in and near the Canal Zone. The first bombs dropped were from 10 Squadron's Canberra WH853, the target being Almaza airfield on the outskirts of Cairo. In addition to the bomber squadrons involved in the operation, one Canberra photographic-reconnaissance squadron was active: this was No.13 with PR.7s, which had formed in Cyprus earlier in the year. The only Canberra lost during the operation was WH799 of 13 Squadron, which was shot down by a MiG-15. After five days of attacks on Egyptian airfields, the Egyptian Air Force was rendered ineffective, and British and French

troops landed to occupy the Canal Zone. However, following United Nations' intervention a ceasefire was declared on 6 November. During the following weeks the Canberra squadrons returned to the United Kingdom, the last reaching its home base in January 1957.

During April 1956, Shorts delivered its last B.6, this aircraft, WT213, being the sixty-ninth of this type built by the company. Production continued with WT337, the first of the twelve B(I)8s ordered from Shorts under direct sub-contract from English Electric. WT337 was delivered in August, the remaining aircraft being completed at a rate of about one a month. Further Canberra work at Belfast after the B(I)8s was assured in November, when English Electric's contracts for forty-three PR.9 aircraft were transferred to Shorts.

The five-hundredth Canberra built by English Electric was an export B(I)8 completed in August 1956. By the end of the year, 512 aircraft had been produced. After the completion of the last British B(I)6 and PR.7 aircraft during the year, the only versions remaining in production against British orders were the T.4 and the B(I)8. The most significant event of 1956 was the visit to the United Kingdom in June of the Indian Defence Secretary, during which discussions regarding a proposed large Indian order for Canberras took place. In the months that followed, English Electric began work in anticipation of receiving a contract from India, which was eventually placed in January 1957.

The Indian order for 80 aircraft was the biggest Canberra export contract ever received, being larger than all other export orders for new aircraft added together. The contract was worth over £20 million, and was won in the face of a Russian offer of Ilyushin Il-28 aircraft at a very competitive price. Three versions of the Canberra were ordered comprising sixty-five B(I)58s, eight PR.57s and seven T.4s. (The mark numbers above 50 were allocated to versions specially developed for export, and the Mk 58 and Mk 57 aircraft were designed to meet Indian requirements). Generally

Two of the Indian Canberra B(I)58s, IF909 and IF910, pose for the camera before delivery in November 1957. All the Indian Canberras were finished in a silver overall paint scheme. *(British Aerospace)*

similar to the B(I)8, the B(I)58 had an autopilot and extra navigational equipment fitted, and other miscellaneous changes. Trial installations of the special features of the B(I)58 were made in the British B(I)8 WT338 by Boulton Paul, this aircraft eventually being diverted to the Indian order and delivered as a B(I)58. A further eighteen British B(I)8s were diverted to India, replacement aircraft being ordered for the RAF. The PR.57 was based on the PR.7, but in addition to having the autopilot and extra navigational equipment of the Mk 58, a modified electrical system, a radio altimeter and other extra items of equipment were fitted to the aircraft. Three late production PR.7s built for the RAF were transferred to the Indian order. The Indian T.4s were standard aircraft and were not, therefore, redesignated. Two T.4s on the production line were diverted to India and two replacements were ordered for the RAF. Thanks to the diversion of British aircraft and the work done in 1956, the first deliveries to India were made in April 1957.

More records were set in 1957. On 25 May, WT528 *Aries V* set up a new Tokyo-to-London record, routing via Alaska, northern Canada and the North Atlantic. The second record achieved in 1957 was the third world altitude record to be held by the Canberra and was set by WK163, the aircraft being used by Napiers to flight test its Double Scorpion rocket engine. On 28 August, during a flight from Luton, WK163 reached an altitude of 70,310 ft. The pilot for this flight was M. Randrup, Napier's chief test pilot.

Another altitude record, although unofficial, was achieved in 1958. The aircraft concerned was the B.6 WT207 which had been used by 76 Squadron for high-altitude air sampling in Australia. On 9 April, during a flight over Derbyshire, an explosion occurred, which necessitated the pilot and navigator using their ejector-seats to escape from the aircraft. This was the highest ever successful emergency ejection, as the flight was taking place at 56,000 ft. This rather unenviable record stood for at least 20 years. After ejecting into an ambient atmospheric temperature of -57°C, the two aircrew were in free-fall for four minutes. When they had descended to 10,000 ft their parachutes opened automatically. Neither suffered any serious injury, although both had slight frostbite.

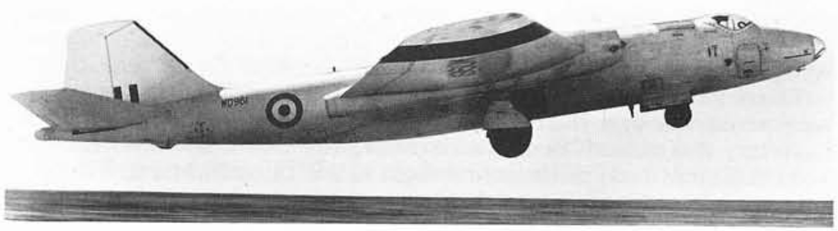
A second important export contract was received by English Electric early in 1957, this being the first overseas repeat order for Canberras. In

2E-39 was the second of two Canberra T.4s delivered to Venezuela. It is seen here before leaving Warton in February 1958. Colour scheme was silver overall with a yellow band round the rear fuselage. (*British Aerospace*)

February, Venezuela ordered eight B(I)8s and two T.4s, these aircraft being intended to supplement the six B.2s delivered to the Venezuelan Air Force in 1953. Deliveries of the B(I)8s were completed in January 1958, and the second of the two T.4s was ferried to Venezuela in February by Hackett, Moneypenny and a Venezuelan officer. On the final stage of this flight a point-to-point speed record was established between Washington and Caracas, this being the nineteenth and the last of such records set by the Canberra.

The rundown of the RAF Canberra bomber force based in the United Kingdom was intensified during 1957, ten squadrons being disbanded. However, four new Canberra units were formed in the Middle East, and another in the Far East. The Canberra B.2s of the wing of four squadrons formed at Akrotiri in 1957 were the first to be permanently based in the Middle East, and the wing was to remain active for 12 years. In the Far East, the first Canberra unit was 45 Squadron, which received B.2s at Tengah, Singapore, in November. This squadron was to fly Canberras for 12 years, and during the period up to 1960 was engaged in operations against the terrorists in Malaya. Continued deliveries of B(I)8s to the RAF during 1957 permitted 59 Squadron in Germany to exchange its B.2s for B(I)8s, thereby becoming the second squadron with this mark of aircraft.

Shorts delivered the last of its twelve B(I)8 aircraft in May 1957, and in the same month completed the first Canberra U.10. The Mk 10 was the first version to be produced by modification of earlier aircraft, the U.10s being conversions of B.2s withdrawn from bomber squadrons. The role of the U.10 was that of unpiloted target drone, for use in the development trials of guided weapons. WJ624 was the first aircraft to be so converted and was used for the initial tests of the radio-operated controls of the U.10. Progress towards ground-controlled flight without a pilot on board the aircraft was made in several stages, the first being a pilot flying the aircraft by means of a supervisory control panel installed in the cockpit. This panel enabled the pilot to operate the aircraft's controls by means of push buttons, simulating the 13 basic inputs the controls would eventually receive by way of the radio link. The next step was to introduce the radio link and fully control the aircraft from the ground, althoug a pilot flew in the aircraft ready to take over should any fault develop in the remote control system. This phase of U.10 development was done with WJ987 in 1958 at RAE, Bedford, but the final step to pilotless ground-controlled flight was not made until 1959.



Canberra U.10 WD961 making a pilotless take off at Woomera. (*Short Brothers & Harland*)

By 1957, English Electric had virtually completed its British Canberra contracts, and all of the 34 aircraft produced during the year were for export. Late in 1957, Rhodesia ordered fifteen Canberra B.2s, but these were to be supplied by the RAF from stocks of aircraft withdrawn from service and were not to be handled by English Electric. However, in January 1958 the company received a further export contract, this time from New Zealand. Nine B(I)12 and two T.13 aircraft were ordered, these marks being modifications of the B(I)8 and T.4 respectively to comply with New Zealand requirements. The aircraft were ordered through the British Ministry of Supply and the contract also included one extra B(I)8 for the RAF. This aircraft was to be a replacement for an RAF B(I)8 which was to be converted into the first B(I)12. Before delivery of the B(I)12s, New Zealand received fifteen Canberra B.2s on loan from the RAF. These aircraft were to be operated by 75 Squadron RNZAF based at Tengah, Singapore, in co-operation with 45 Squadron RAF against the Malayan terrorists. No.75 Squadron returned to New Zealand late in 1961. The B.2s were returned to the RAF and the Squadron afterwards received B(I)12s and T.13s.

In 1958, the UK-based Canberra bomber force was reduced to seven squadrons by the disbandment of Nos.61 and 199. No.542 Squadron, a reconnaissance unit, also disbanded. However, one new Canberra squadron was formed, this being No.245 at Tangmere, which operated B.2s under Signals Command. In Germany, 16 Squadron reformed in March at Laarbruch with B(I)8s, becoming the third squadron equipped with this version. Also at Laarbruch, 69 Squadron with PR.3s was renumbered 39 Squadron and promptly moved to Luqa, Malta, as part of RAF Middle East. The Canberra strength of this Command was thereby increased to six squadrons. By the end of 1958 the larger part of the RAF Canberra force was based overseas. These overseas commands were to fly the majority of the RAF's Canberras for the remainder of the aircraft's operational life.

During 1957 and 1958, the operational effectiveness of the bomber and interdictor Canberras was improved by modifying the aircraft to enable them to carry tactical nuclear weapons, and also to make attacks at low level by means of the Low Altitude Bombing System. A few aircraft at a time left the squadrons concerned to receive the necessary modifications, 9 Squadron being the first to use the LABS technique after having its aircraft modified. During April and May of 1958, the Canberras of the RAF Flying College, Manby, made further long-distance flights, continuing the tradition established in earlier years by the College. The B.2 *Aries IV* made a return flight to New Zealand and the PR.7 *Aries V* a round-the-world flight of over 28,000 miles. As in previous years, the purpose of the flights was to develop navigational methods in areas of the world without radio navigation aids.

The second mark of Canberra to be derived from B.2s withdrawn from service was the T.11 dual purpose trainer. Boulton Paul Aircraft did the necessary design and modification work, the first B.2 converted being WJ610. This aircraft made its first flight as a T.11 on 29 March, 1958. The primary role of the T.11 was the training of the navigators of all-weather fighters in the use of airborne interception radar. For this purpose an AI.17 radar set was carried in a lengthened nose, the radar scanner being

mounted behind a large conical radome. The secondary role was that of general crew trainer. A crew of four, two of which were pupils, was carried in both roles. Both the T.11 and U.10 made their first public appearances at the 1958 Farnborough air show.

The first production PR.9 was completed by Shorts in July 1958. The first flight of the aircraft, XH129, was made at Belfast on 27 July, the pilot being English Electric's Peter Hillwood. Intended to fly photographic-reconnaissance missions at altitudes up to 70,000 ft, the PR.9 had a modified wing, powered flying controls and engines of increased power to permit operation at this altitude. These features had been tested on WH793, the prototype PR.9, which had first flown in 1955. The wing span was increased by 5 ft 5 in compared with earlier Canberras, and the wing chord inboard of the engine nacelle was 3 ft 1 in greater than that of the standard wing. The RA.24 Avon Mk 206 engines provided 2,550 lb more thrust than the RA.7 Mk 109 engines of the PR.7. The front fuselage was generally similar to that of the B(I)8, and enabled the PR.9 to carry more equipment than the PR.7. In addition, the pilot's revised canopy provided improved view from the cockpit. The centre fuselage, rear fuselage and tail were the same as the PR.7s, as was the overall length. Camera bays, with provision for carrying several types of cameras, were situated fore and aft of the bomb-bay, which contained a fuel tank and racks for flares and photographic-flashes. Equipment changes introduced in the PR.9 included improved pressurisation and air conditioning, an autopilot, extra navigational equipment, radio altimeters and a modified electrical system. The increased power of the RA.24 engines was intended to permit a general improvement in performance, particularly at high altitudes, and the systems changes were made to take advantage of the increased performance.

After several weeks of test flying at Belfast, XH129 was transferred to English Electric for further testing from Warton. On 9 October, 1958, during a low-level test flight, the aircraft was lost in a crash into the Irish Sea near Warton. The pilot, D.M. Knight, ejected safely, but the navigator, P.H. Durrant, who had no ejector-seat, could not escape from the aircraft quickly enough and was killed. Following the accident, the front fuselage of the PR.9 was redesigned to provide an ejector-seat for the navigator. After this alteration, the front fuselage still resembled that of the B(I)8 externally, but the internal layout was extensively changed. The crew entry hatch, which was also the navigator's emergency escape route, was omitted, and each crew member was provided with his own separate access. The pilot's canopy was hinged at its rear edge and the pilot entered his cockpit by way of an external ladder and opening the canopy. An ejector-seat for the navigator was situated in a separate compartment in front of the cockpit, entry to this being achieved by hinging the extreme nose of the aircraft sideways. The ejection path of the navigator in case of emergency was through the frangible roof of the compartment. The modifications were incorporated in the PR.9s on the production line and deliveries of modified aircraft started late in 1959. However, in March 1958, before the crash of XH129, orders for the PR.9 had been reduced by twenty, and only twenty-three aircraft were to be built.

During 1958, thirty-eight B(I)58 aircraft were delivered to India, and No.5 Squadron of the Indian Air Force became the first unit to operate the

type. Two further squadrons, Nos.16 and 35, were formed later as sufficient aircraft and trained aircrews became available. Also delivered in 1958 were two T.4s and two PR.57s.

In Australia, a third squadron of Canberra B.20s was formed in July 1958, this being No.1 Squadron RAAF, at Amberley. The Government Aircraft Factory completed A84–248, the last of its contract for forty-eight B.20s, in December. The GAF afterwards produced seven Canberra trainers, which were generally similar to the British T.4. The Australian trainers, designated T.21, were produced by modifying five B.20s and two B.2s, the last two aircraft being received from the United Kingdom in 1951–52.

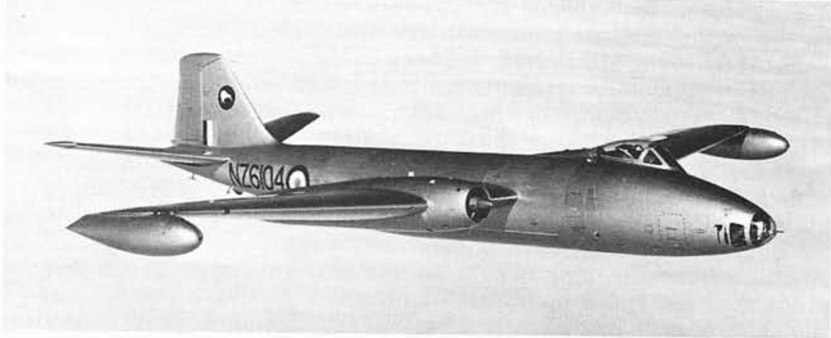
Canberra production by English Electric during 1958 totalled 44 aircraft, of which 29 were for India. The remainder were B(I)8s for the RAF, being some of the replacement aircraft for those diverted to India. Only one new Canberra was completed by Shorts in 1958, this being the first production PR.9. Although Shorts was also engaged in modifying Canberra B.2s to U.10 drones, its main production effort was then centred on sub-contract manufacture of the Bristol Britannia.

The tenth anniversary of the first flight of the Canberra was reached on 13 May, 1959, and the achievements of the aircraft in the course of these ten years were particularly impressive. Over 1,300 had been built by six manufacturers in three countries. Twenty-four versions of the aircraft had been developed for service in ten countries, at least seven different roles being performed. In addition, the Canberra had proved to be an exceptionally versatile flying test-bed for experimental work; the range of equipment which had been tested on Canberras included such diverse items as jet and rocket engines, ejector-seats, guided missiles, radar sets and flight-refuelling gear. During the decade, Canberras had made 22 officially recognised record flights, more than any other jet aircraft.

Canberra manufacture continued during 1959, the aircraft produced being for India, New Zealand and the RAF. A B(I)8, XM936, was the last Canberra built for the RAF, being delivered in April. Changes in RAF Canberra squadrons in 1959 were limited to further reductions of the bomber force based in the United Kingdom, three squadrons being disbanded, reducing the force to four squadrons. At the end of the year twenty-one RAF squadrons, fourteen of which were based overseas, were operating Canberras. Only one new Canberra unit was formed in 1959, this being 228 Operational Conversion Unit at Leeming, Yorkshire. This OCU trained aircrews for Javelin all-weather fighters, and received eight Canberra T.11s which were used for instruction in radar interception techniques.

By June 1959, delivery of the fifteen Canberra B.2s ordered by Rhodesia was complete, the aircraft having been prepared for despatch by RAF maintenance units. Rhodesia had also ordered three T.4s, which were to be obtained by modifying ex-RAF B.2s. These aircraft went to English Electric at Samlesbury in 1959 to be fitted with newly-built Mk 4 front fuselages. The last of the 80 Canberras ordered by India was delivered in September, the aircraft being the final B(I)58, IF984. Deliveries of T.4s and PR.57s to India had been completed earlier in 1959.

The first of the B(I)12s ordered by New Zealand was produced in 1959 by modifying the RAF B(I)8 WT329 as the trial installation aircraft for the



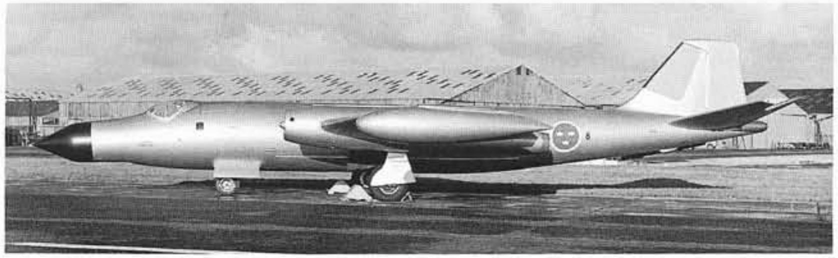
A Canberra B(I)12 for the Royal New Zealand Air Force on a pre-delivery test flight in August 1959. The New Zealand B(I)12s and the T.13s were finished silver overall. (*British Aerospace*)

Many of the Canberras delivered in silver paint schemes were later camouflaged. Shown here is a typical example, RNZAF B(I)12 NZ6106. By 1967 the New Zealand aircraft were camouflaged, although the fin emblem of a white kiwi on a black disc was retained. (*MAP*)

Mk 12. The features which distinguished the B(I)12 from the B(I)8 were the addition of an autopilot and changes to the navigational equipment. WT329 eventually became NZ6101 and was delivered as a standard B(I)12. The first newly-built B(I)12 was NZ6102 which was completed in July 1959 and was handed over to the RNZAF in September. The last of the eight aircraft was completed in November. Only one of the two T.13s ordered by New Zealand was newly-built, the other being produced by modifying a T.4. An autopilot and an extra fuel tank installed in the bomb-bay were among the main features of the T.13 Due to the delays experienced in the delivery of the T.13s, two RAF T.4s were loaned to the RNZAF in 1959, and were used at Wigram for crew training. The B(I)12s were used to equip No.14 Squadron RNZAF at Ohakea, this unit being destined to fly these aircraft for ten years.

The New Zealand aircraft NZ6109 and NZ6151 were the last Canberras off the English Electric production line, which closed at about the end of 1959. At that time 616 aircraft had been manufactured. However, towards the end of production, major assemblies for 15 aircraft to a basic Mk 8 standard were built, against anticipated future contracts. These components were stored pending the receipt of orders and were not fully equipped or finally assembled until the customer's requirements were known. The Canberra was manufactured at Preston and Samlesbury for just over nine years, the average production rate during this period being 5.6 aircraft a month, the maximum in a single month having been 16 aircraft. From the initial flight of the first prototype to the end of production ten and a half years had elapsed.

Contracts to be met from the 15 stored aircraft were not long in coming, as New Zealand ordered two extra B(I)12s late in 1959, and in the same year Peru placed an order for one B(I)8. This last aircraft was to replace one of the Peruvian B(I)8s which had been delivered in 1956 but subsequently lost in a crash. A third export order was received, but this was for two ex-RAF B.2s, to be delivered to Sweden. These aircraft were to be externally similar to the T.11, with a large radome on a lengthened nose, but they were intended for the flight-testing of radar and other avionic equipment, and were identified by the Swedish designation Tp52. They were delivered in the spring of 1960 and remained in service for ten years.



The first of the two Tp52 aircraft supplied to Sweden as radar test-beds. This aircraft was a conversion of the ex-RAF Canberra B.2 WH711, the new serial being 52001. (*British Aerospace*)

Deliveries of Canberra U.10s from Shorts' Belfast factory started in November 1958, when WD961 was despatched. Most U.10s were delivered to the Woomera weapons testing range in Australia, and it was there that the first pilotless ground-controlled flight of a U.10 took place. The flight was made on 25 June, 1959, the aircraft concerned being WD961. Further deliveries to Woomera were made in 1959 and 1960, the U.10s being used as targets in the trials of several types of ground-to-air missile, including the English Electric Thunderbird. In addition to about seventeen U.10s delivered to Woomera, six aircraft were allotted to 728B Squadron of the Fleet Air Arm based in Malta. These aircraft were operated in the same manner as those in Australia, being used in the development trials of the Seacat and Seaslug ship-to-air missiles. For these trials the target aircraft were fitted with hydraulically-powered flying controls similar to those of the PR.9. The six modified aircraft were designated U.14. The first U.14

for 728B Squadron, WH921, was delivered to Malta on 25 May, 1961, and the remaining aircraft were delivered there by September. The first to make a pilotless flight was WH720, on 3 August, 1961. By the end of 1961 the trials were complete and 728B Squadron was disbanded. The five remaining U.14s were returned to Britain and placed in storage. WH921, the one aircraft which did not return, had been shot down by a missile launched from the trials ship HMS *Girdle Ness*. A few years after entering service, the Canberra U.10 and U.14 were redesignated the D.10 and D.14 respectively. (Shorts completed its last Canberra U.10 conversion in July 1962, after which Canberra work ceased at Belfast).

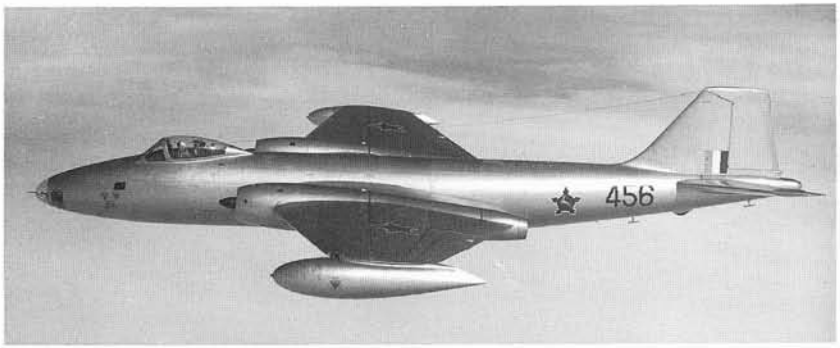
Three modified PR.9s were delivered by Shorts in 1959 and a further sixteen followed in 1960. The last PR.9 was XH177, which was delivered in December 1960. This aircraft was the last new Canberra to be built, English Electric's production line having closed about a year before. PR.9 aircraft entered service during 1960, gradually replacing the PR.7s of 58 Squadron at Wyton. Only one other significant unit change took place in 1960, this being the disbandment of 76 Squadron equipped with the Canberra B.6. After being withdrawn from service, most B.6s were modified to operate in the low-level tactical strike role. The work was undertaken by Bristol Aircraft at Filton and Marshalls at Cambridge, the modified aircraft being known as the Mks 15 and 16.

The Canberra B.15 differed from the B.6 only by the extra equipment and armaments fitted for the changed operational role. A doppler navigation system with a Decca roller map display was added, and additional radio and radar equipment was fitted for both navigational and weapon delivery purposes. Provision was made for three cameras to be carried, only one having been fitted to the B.6. Attachment points for a pylon were built into each wing, the installation being similar to that of the B(I)6. The B.16 differed from the B.15 in only two significant aspects, one of which was the fitting of a sideways-looking radar to the B.16. The second difference was that the B.15 had two navigator's ejector-seats, whilst the B.16 had only one, although both marks carried two navigators. During conversion to Mk 15 and 16, an extensive general overhaul of the airframe was done, the resulting aircraft being capable of giving up to ten years of effective service. The first B.15 conversion was completed in October 1960, and during the period to 1963 a further 38 were produced. In the same period, 19 aircraft were converted to B.16s.

During 1959 and 1960, a special flight of six RAF Canberras was engaged in *Operation Swifter*, which took place in Libya and was organized by the RAE, Farnborough. The operation involved a large number of high-speed flights at low altitude, the purpose of the flights being to investigate the effects of turbulence experienced under these conditions on both airframe and aircrew. The results of the *Swifter* flights were of general applicability to all future aircraft intended for low-altitude operations and the TSR.2 was one of the first designs to benefit from the *Swifter* research.

The single B(I)8 ordered by Peru was delivered in November 1960. This B(I)8, and the two B(I)12s ordered by New Zealand in 1959, were from the 15 aircraft built for stock. Contracts for the remaining 12 aircraft were received in 1961 from India and South Africa, each ordering six B(I)12s. Only five Canberras were delivered by English Electric during 1961, these

South African Canberra T.4 458 was originally WJ864. All SAAF Canberras were finished silver overall, the T.4s having red bands round the rear fuselage and outer wings, and a red panel on the fin leading edge.



The last of the six Canberra B(I)12s supplied to South Africa. (*British Aerospace*)

being the three T.4s ordered by Rhodesia and the two previously mentioned B(I)12s for New Zealand. The Rhodesian aircraft, which had been modified from RAF B.2s by English Electric, and the New Zealand Canberras were delivered in the spring of 1961.

The first of the six B(I)58s, BF595, produced for India from the 15 stock aircraft made its first flight in January 1963. Late in 1962, India had ordered a further three Canberras, this contract being met with ex-RAF aircraft. The first of this order was a T.4, which was despatched soon after the last of the B(I)58s had been delivered in the summer of 1963. The PR.57s, modified from PR.7s, were delivered in the spring of 1964 to complete the contract.

South Africa placed a second order, for three T.4s, early in 1963. This was to be met with ex-RAF T.4s. The first of the six South African B(I)12s, 451, made its initial flight in August 1963. The remaining aircraft were completed at monthly intervals, the last, 456, making its first flight on 3

Built as a Canberra B.6, WJ756 was converted to a B.15 in 1961. The aircraft is seen here firing rockets from the underwing pods which were a feature of the B.15. When photographed in 1966 WJ756 was serving with the Akrotiri Strike Wing.

February, 1964. This was the last new Canberra to be completed anywhere. Deliveries of the T.4s and B(I)12s were finished in the spring of 1964, all of the aircraft entering service with No.12 Squadron of the South African Air Force.

During 1961, the final three Canberra squadrons in the United Kingdom operating as bomber units were withdrawn, the last squadron to disband being No.35 in September. The Canberra had then served the RAF as a light bomber for over ten years. Although outdated as a high-altitude bomber by 1960, the Canberra was still effective at low altitudes, and it was to continue to operate in low-level roles for the next ten years. Most of the B.2 aircraft withdrawn from service were placed in storage, later being modified for specialised roles, sold for export, or scrapped. Nearly all of the B.6s withdrawn were modernised to B.15 and B.16 tactical strike aircraft. The first RAF unit to re-equip with these versions was 32 Squadron at Akrotiri, in the summer of 1961. One new Canberra squadron was formed in 1961, this was No.81 at Tengah which received PR.7s and was the only Canberra PR squadron in the Far East. At the end of 1961, the RAF had eighteen Canberra squadrons, of which only three were based in the United Kingdom. Seven were based in Germany, six in the Mediterranean and two in Singapore. All of these squadrons were to remain unchanged for the next seven years.

Many of the Canberras withdrawn from RAF bomber squadrons were allocated to research and development work. By 1961, about 20 different Ministry establishments and aircraft companies were using Canberras for such work, at least 50 aircraft being employed. Although most of these Canberras had served with RAF squadrons, some were new aircraft straight from the manufacturers. An example of such an aircraft was XH132, a PR.9 which was delivered to de Havilland in late 1961, and was used in the development of the Red Top air-to-air missile. The aircraft had been modified before delivery, being known as the Short SC.9 after modification.

XH132, the Canberra PR.9 used in the development of the Red Top missile. Special radomes can be seen fitted to the nose and wingtip tanks. (*British Aerospace*)

The second of the two RAF squadrons to receive PR.9s was No.13, at Akrotiri. This squadron re-equipped in January 1962, and later in the year 6, 73 and 249 Squadrons, also at Akrotiri, received B.15 and B.16 aircraft. With No.32, these squadrons made up the Akrotiri strike wing, which continued to operate B.15s and B.16s until disbanded in 1969. One further squadron re-equipped in 1962, namely No.45 in Singapore, which received B.15s. The four Akrotiri strike wing squadrons and 45 Squadron were the only units to operate B.15s and B.16s.

In January 1962, an official announcement was made that Canberras were to be fitted with the Nord AS.30 air-to-ground missile. This weapon was for use in the strike role, and was a solid-propellant rocket with radio command guidance. A trial installation of the AS.30 was made by Boulton Paul on WH967, the necessary modifications included making provision for an extra under-wing pylon to be fitted further outboard than the existing one. Additional B.15s received their AS.30 modifications at Samlesbury.

The Canberra PR.9 was found in service to be not entirely suitable for operation at high altitudes, although this version had been intended for such use. As a result, the PR.9s of 58 Squadron in the United Kingdom were transferred to 39 Squadron in Malta, replacing PR.3s in that squadron in March 1963. No.58 Squadron reverted to PR.7s. Together with No. 13 Squadron, No. 39 operated the PR.9 at medium and low

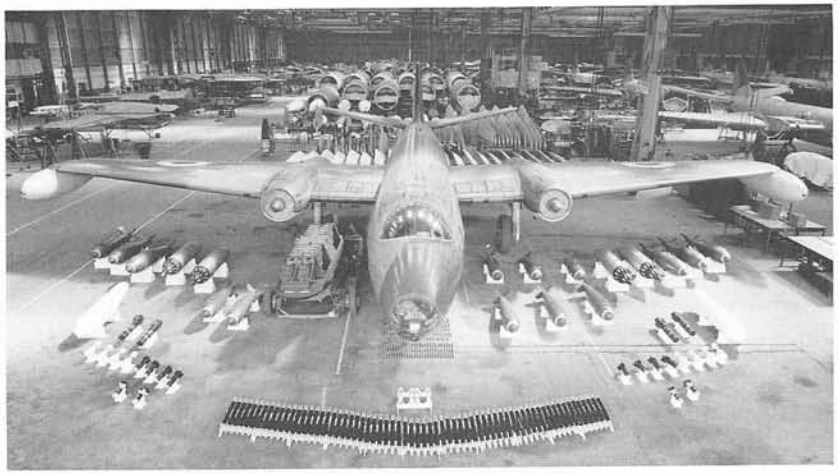
A bomber in fighter squadron markings. Canberra B.2 WH666 was used by No.56 Squadron (Lightnings) for target facilities work. The cover on the starboard engine intake was not a good fit! (*MAP*)

WH664, a Canberra T.17, with the type's distinctive nose radome. Carrying the markings of No.360 Squadron on the fin, the aircraft is in the standard RAF camouflage scheme. (*British Aerospace*)

altitudes. The two squadrons formed the PR element of RAF Middle East, providing support for the Canberra strike wing based in Cyprus, and also for other units in the area. In April 1963, the Target Facilities Squadron, which operated Canberras in RAF Fighter Command, was numbered 85 Squadron. The only Canberra unit in Fighter Command, this squadron flew simulated attacking missions against the radar and fighter defence systems of Fighter Command, providing practice targets for tracking and interception training.

During the early 1960s the bulk of Canberra work at Samlesbury was concerned with modifications and overhauls, the assembly of the last few new aircraft being of secondary importance. Late in 1963, the scope of the work on aircraft returning to Samlesbury was greatly increased with the start of a new programme. This involved the refurbishing and modification of a number of ex-RAF B.2s to produce a new mark of Canberra, the T.17. Intended for use in the electronic countermeasures role, these aircraft were to feature extensive modifications. The most distinctive of these was to the nose of the aircraft. It was lengthened forward of the canopy and fitted with a large hemispherical radome and four small blister radomes. A B.2, WH863, was used as a development aircraft for the T.17, which after modification at Samlesbury, began test flying at Warton in the autumn of 1964. The first fully modified T.17, WJ977, flew on 3 September, 1965, at Samlesbury. After a period of development flying by the company, the aircraft was delivered in the spring of 1966 to the A & AEE at Boscombe Down for official assessment. The first T.17 delivered from Samlesbury to an operational unit was WJ988, which joined 360 Squadron at Watton in December 1966. This squadron had been specially formed earlier that year to operate T.17s and was fully equipped by the end of 1967. The duties of 360 Squadron, which was jointly manned by the RAF and the Royal Navy, were concerned with training all branches of the armed forces to operate in an hostile electronic countermeasures environment. Deliveries of T.17s were completed in the spring of 1968, and totalled 24 aircraft.

The cancellation in April 1965 of the TSR.2, which had been intended to replace the Canberra in RAF service, was a serious blow to both the RAF and the company. A replacement for TSR.2 in the form of the Anglo-



Canberra B(I)6 WT316 was one of the ex-RAF Canberras acquired by British Aircraft Corporation for refurbishing. The armament laid out with the aircraft include the four-cannon pack, bombs, rocket pods, flares and practice bombs. In the background of this view, taken in No.4 hangar at Samlesbury, are major components of about 20 aircraft being refurbished. *(British Aerospace)*

French Variable Geometry Aircraft and General Dynamics F-111 did not materialise and resulted in the Canberra being retained as a large part of the front-line strength of the RAF until 1969, when Phantoms and Buccaneers became available. At BAC Preston Division (English Electric Aviation had been renamed in December 1963), the cancellation of TSR.2 inevitably had serious consequences, but ironically the effects were to some extent alleviated by an increase in Canberra work in the Division's factories. Before the cancellation two further orders for refurbished aircraft had been received, and during the later part of 1965 the volume of Canberra work reached a level which had only been exceeded in the days of full production. As the RAF released earlier marks of Canberra from storage, many were bought by BAC for refurbishing and sale abroad, and the first of these aircraft were among those in the factories in 1965.

Refurbished Canberras offered to overseas air forces by BAC were remanufactured to a high standard. During refurbishing the airframe was completely stripped of equipment, and critical 'lifed' items were replaced with new parts. A wide range of the latest radar, navigation and weapon-delivery equipment could be fitted to suit customer requirements, and numerous alternative stores combinations were also offered. Additionally, any special modifications or equipment required by the customer could be incorporated during the rebuild. The refurbished export aircraft had a minimum service life of ten years, and BAC guaranteed spares supply and technical support for that period. The Canberra remained an effective aircraft for tactical, interdictor, counter-insurgency and photographic-reconnaissance roles. In the export market the refurbished Canberra had few serious competitors in these roles, even from aircraft of more recent design. The high cost-effectiveness of the Canberra made it particularly attractive to less sophisticated air forces in many parts of the world.

Refurbished Canberra B.2s ready for delivery from Warton in September 1966. YA153 was for the German Federal Republic, 236 for Peru, and 1339 for Venezuela. *(British Aerospace)*

Venezuela was the first customer for refurbished aircraft, placing an order for 14, of which 12 were to be B.2s, the remaining two being PR.3s. This was the third contract for Canberras from Venezuela. In 1965, export contracts were received from Peru and the German Federal Republic. The Peruvian order was for six B.2s and two T.4s, Peru having previously bought new B(I)8s. Germany, however, was a new customer and intended to use the three B.2s ordered for experimental work.

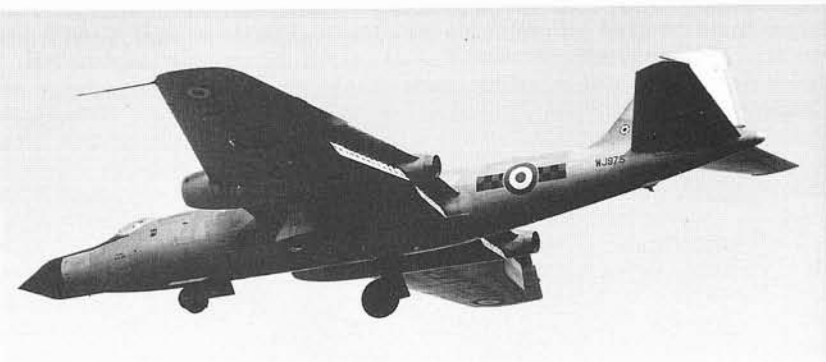
In mid-1965, work started on a further refurbishing and conversion programme, the end product of which was to be another new mark, the TT.18. As indicated by the prefix TT, this version was to be a target tug, and for this role it was to be equipped with the Rushton towed-target system. Manufactured by Flight Refuelling Ltd, this system had two principal components, namely a streamlined winch pack and the target itself. In the Canberra installation, one winch pack and target was carried on a pylon under each wing. Sufficient cable was carried in the pack to enable the torpedo-shaped target to be towed nearly 10 miles behind the aircraft. The target could be used for practice with guns, rockets or missiles, fired from

The first Canberra TT.18 conversion completed at Samlesbury, WK122, with the Rushton winch pack and target fitted underwing. From 1974 RAF TT.18s started to lose their colourful paint scheme, being repainted in matt-finish camouflage. *(British Aerospace)*

the ground, ships or aircraft. The conversion of B.2 WJ632 to become the first TT.18 was completed at Warton in March 1966. This aircraft was the only one to be converted at Warton, the remainder of the order for 18 of this type being refurbished and converted at Strand Road and Samlesbury. WJ632 made its first flight as a TT.18 on 21 March and it was displayed at the Farnborough air show in the following September.

Canberras were again engaged in operational flying in September 1965, during the brief war between India and Pakistan. An unusual feature of this conflict was the fact that both sides used Canberras, those of the Indian Air Force having been obtained from the United Kingdom, whilst the Pakistan Air Force operated a number of B-57s, the American-built version of the Canberra. Although the hostilities lasted only a few weeks, a number of battles took place, some of the fiercest of which were between the opposing air forces. At the end of the war, both sides claimed to have destroyed numerous aircraft belonging to their opponents, these claims including Canberras and B-57s. December 1971 saw a renewed outbreak of hostilities between India and Pakistan. As in the earlier conflict, the air forces of both sides were particularly active, especially in the western combat areas. Again Indian Canberras and Pakistani B-57s were involved, and each side claimed to have destroyed a number of its opponent's aircraft. However, air power was not to prove the decisive factor, as the success of the Indian army in the eastern area was largely responsible for the ending of the war after some two weeks of fighting.

Early in 1966, work started at Warton on yet another modification, the aircraft concerned being WH903, a T.11. By 1966 all the T.11s were serving with 85 Squadron on target facilities work, for which their interception radar was unnecessary. Accordingly, this radar was removed from WH903, being replaced by ballast. Other changes incorporated included the fitting of improved ejector-seats and alterations to the electrical and oxygen systems. The modified aircraft was redesignated T.19, this being the second change of mark for the aircraft, as all T.11s had been originally built as B.2s. The T.19 was externally similar to the T.11, retaining the distinctive nose radome, although there was no longer any radar behind it. WH903 made its first flight as a T.19 in June 1966, and



Originally built as a Canberra B.2, WJ975 was later converted to a T.11 and is seen here as a T.19. Operated by No.85 Squadron, the aircraft is seen landing at Binbrook in 1970. (*MAP*)

returned to 85 Squadron in July. During 1967 and 1968, the remaining six T.11s serving with 85 Squadron were modified to T.19 standard by Marshalls at Cambridge.

Deliveries of refurbished B.2s to Venezuela began at the end of 1965. Further aircraft were delivered during 1966, entering service with the 40th Bomber Squadron of the Venezuelan Air Force. The two PR.3s ordered were despatched in the autumn of 1966, and B.2 deliveries were completed in the spring of 1967. The first Peruvian aircraft delivered of those ordered in 1965 were the two T.4s, which were despatched in April and May of 1966. These aircraft were followed by five B.2s, all of which had arrived in Peru by early 1967. The sixth Peruvian B.2 was used for trials work before being delivered some months after the other aircraft.

D-9567 was originally supplied to Germany as YA153 in 1966, for trials work. By the time it was photographed visiting Warton in January 1973, it had changed identity and acquired an orange overall paint scheme. At that date it was operated by the Military Geographic Service for photographic survey work, with camera mountings in the rear part of the bomb-bay. (*British Aerospace*)

The three B.2s for Germany were overhauled and repainted by Marshalls at Cambridge during 1966. After completion of this work the aircraft were handed over to BAC at Warton for final checks before delivery. The first two aircraft were despatched in September and the third in December. All three aircraft entered service with the experimental unit, Erprobungstelle 61, at Oberpfaffenhofen.

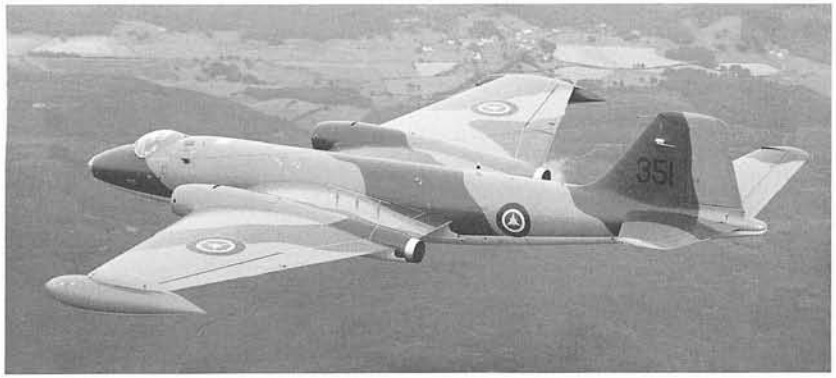
Very few Canberras have carried British civil registrations. The first to do so was WD937 in October 1966. This aircraft, the ninth production B.2, was used by English Electric for miscellaneous work in support of British Canberra, Lightning and TSR.2 contracts. Among the varied tasks performed by WD937 were flight testing of trial installations, air-to-air photography, weather flights, chase flights, and survey work to select suitable low-level routes for the flight testing of TSR.2. When required for tasks in support of export Lightning contracts, WD937 was transferred to BAC ownership and registered G-ATZW. This registration was carried until 1969, when the aircraft was withdrawn from use. BAC first used temporary class B civil registrations in 1967: the first Canberra to carry such markings, namely G27-3, was 1529, the last of the refurbished B.2s delivered to Venezuela.

In April 1967, Canberras again went on active service, the aircraft on this occasion being Australian. No.2 Squadron RAAF moved to Phan Rang air base in South Vietnam and began operations in support of

The only Canberra permanently on the British civil register. G-ATZW, formerly the B.2 WD937, was finished gloss black overall, with yellow lining and white registration. The photograph shows the aircraft at Samlesbury in October 1968, with the TT.18 WJ715 beyond. *(British Aerospace)*

Australian Canberra B.20 A84-245 in the standard dark green and mid-grey camouflage scheme. This aircraft made 52 bombing missions over Vietnam in 1967, while serving with No.2 Squadron, RAAF. *(MAP)*

Stored Canberras at Samlesbury. They are some of those bought by BAC in 1969 for possible resale overseas. Half the aircraft are B(I)6s, the others are B.2, B.15 and B.16s. Most were scrapped in 1976. *(British Aerospace)*



The first of the four Canberra B.52s supplied to Ethiopia, seen on a test flight in July 1968. Finish was similar to that of camouflaged RAF Canberras. *(British Aerospace)*

ground forces in the war against the communists. Although the eight Canberras of No.2 Squadron were only a token force, they proved to be particularly effective, their results comparing favourably with those of the American units alongside which they operated. Under combat conditions the squadron achieved the astonishingly high serviceability rate of 97 per cent, and clearly demonstrated the efficiency of the Canberra in the low-level ground support role.

The next customers for refurbished Canberras were Ethiopia, Peru and Argentina. The contract from Peru was the fourth Canberra order received from that country, but Ethiopia and Argentina were both new customers. Ethiopia's order was for four B.52 aircraft, which were rebuilt B.2s modified to Ethiopian requirements. The first B.52 flew in June 1968 and was delivered the following month. By the end of the year, the remaining three aircraft had been despatched. Work at Samlesbury continued, on completion of the Ethiopian contract, with the six B(I)56 aircraft ordered by Peru. Derived from the B.6, the Mk 56 was equipped to the customer's

One of the B(I)56 Canberras ordered by Peru, 242 displays on its rear fuselage the Class B registration G27-99 used during pre-delivery test flying. *(British Aerospace)*

Lined up at Warton to honour the Canberra's 21st anniversary are G27-111 for Argentina, a Jaguar prototype, a BAC Strikemaster for Kuwait, and a Lightning F.6. G27-111, later delivered as B101, was in a temporary pale blue paint scheme for the occasion. (*British Aerospace*)

Argentine Canberra B.62 B102 flying at the 1970 SBAC Displays at Farnborough. Notable are the twin rocket pods fitted to each underwing pylon and, on the rear fuselage, the civil registration G-AYHP, carried for the show appearance. (*British Aerospace*)

requirements, and was intended for the strike and interdictor roles. The first B.56 was delivered early in 1969 and the order was completed in the summer of 1969. During the year, Peru also placed another contract for one B(I)8, a refurbished ex-RAF aircraft, which was delivered in July 1971. It had been refurbished and fitted with up-to-date equipment, and was re-designated B(I)68. This was the first Mk 8 to be refurbished for sale overseas, as ex-RAF B(I)8 aircraft had not previously been available. A short

The first three Canberra B.62s for Argentina about to leave Warton on their delivery flights in November 1970. Upper surfaces were camouflaged dark green and mid-grey, lower surfaces were light grey. (*British Aerospace*)

time later, Peru placed a further order, for a single T.4. This was an ex-RAF aircraft, and it was delivered in February 1973.

On 13 May, 1970, the twenty-first anniversary of the Canberra's first flight, BAC held a short flying display and a press conference at Warton. These events were to mark the anniversary and to announce the contract signed with Argentina. The order was for ten B.62s and two T.64s. The B.62 was derived from refurbished and modified B.2s, the T.64 being similarly based on the T.4. The highlight of the flying display was a demonstration by Beamont of the first Argentine B.62, B101, which during flight testing also carried the temporary registration G27-111. The second B.62, B102, was exhibited at the Farnborough air show in September 1970, and was registered G-AYHP for demonstration flying. Deliveries to Argentina began in 1970 and were completed in September 1971.

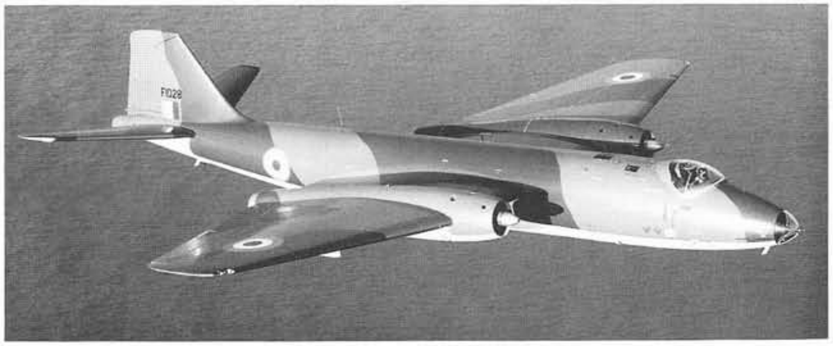
Several Venezuelan Canberras returned to Samlesbury in 1968. Except for one B(I)8, the aircraft were B.2s which had been supplied in 1953. These aircraft were overhauled and fitted with some items of modernised equipment. The B(I)8, which had first been delivered in 1957, was fully refurbished, and completely revised radio and armament were installed.

Originally supplied to Venezuela in 1957 as 4B-39, Canberra B(I)8 0923 was refurbished and modernised by BAC to B(I)68 standard. The photograph shows the aircraft at Warton in 1971, ready for re-delivery to Venezuela. (*British Aerospace*)

The final withdrawal of the Canberra from operational RAF squadrons started in late 1968, when No.45 in Singapore with B.15 aircraft was disbanded. The other units flying the B.15 or B.16, Nos. 6, 32, 73 and 294 Squadrons, which formed the Akrotiri strike wing, disbanded early in 1969. Most B.15s and B.16s were placed in storage after withdrawal from service, but BAC bought some aircraft with the intention of refurbishing them for sale overseas. Some of the B.15s, however, were overhauled and modified to E.15 standard for service with 98 Squadron, the calibration and electronics special duties unit. The first of the E.15s, WH972, was delivered in August 1970. In Germany, 17 and 80 Squadrons with PR.7s, and 213 Squadron with B(I)6s, disbanded in 1969. Nearly all of 213's aircraft were bought by BAC and flown to Samlesbury in December, again with the intention of refurbishing them. No.231 OCU, which had been training Canberra crews at Bassingbourn since 1951, and was, therefore, the oldest RAF Canberra unit, moved to Cottesmore in May 1969. Although reduced in size at Cottesmore, 231 OCU continued to train crews for the remaining Canberra squadrons.

The first exported Canberras to be withdrawn from service were those in New Zealand. Late in 1970, the eight B(I)12 and two T.13 aircraft remaining in service were replaced with Douglas A-4K Skyhawks. The Canberras had not, however, reached the end of their useful lives, for, in November 1970, they were sold to India. Further Canberras were acquired by India from BAC, the contract being for twelve refurbished aircraft, comprising ten B(I)66s (formerly RAF B.15s and B.16s) and two PR.67s (ex-RAF PR.7s). This was the fifth Indian order placed with EE/BAC, and brought the total Indian purchases to 112 (including the ex-New Zealand aircraft). Deliveries of B(I)66s began in late 1970 and were completed, along with the two PR.67s, in the summer of 1971.

Nineteen years after the Canberra entered RAF service, a new squadron was formed in May 1970 with a new mark of the aircraft, an event probably unique in the history of the RAF. These aircraft were TT.18s, and the unit concerned was No.7 Squadron, at St Mawgan, Cornwall. Although 7 Squadron was the first RAF unit to operate TT.18s, they had previously been delivered to the Royal Navy's Fleet Requirements Unit, at Hurn in Hampshire. The FRU, which provided target and other facilities



Indian Canberra B(I)66 F1028 was delivered early in 1971. Colour scheme was dark green/dark grey camouflage on upper surfaces and light grey undersurfaces. *(British Aerospace)*

The second of the two Indian Canberra PR.67s was P1099. It is seen here taxi-ing out at Samlesbury in 1971, carrying the Class B markings G27-184. It was silver overall. *(British Aerospace)*

for Royal Navy training duties, operated a variety of aircraft types. The first TT.18, WK123, was delivered to the FRU on 15 September, 1969, with further aircraft following in 1969 and 1970. Several years later BAC converted four more B.2s to TT.18s for the Royal Navy, these extra aircraft were delivered in 1974. The FRU also received a B.2 and a T.4, which were used for aircrew training and as radar targets.

In the summer of 1971, work started at Samlesbury on another British Canberra refurbishing programme, this time involving a small number of PR.7s. After refurbishment they were fitted with radar in lengthened noses. The modified aircraft were designated T.22, and were intended for use by the Royal Navy Fleet Requirements Unit, by then at Yeovilton, Somerset. The first T.22, WT510, made its initial flight on 28 June, 1973, at Samlesbury. By November, satisfactory acceptance trials had been completed at the A & AEE, Boscombe Down, and during the month deliveries to Yeovilton began. The first aircraft despatched was WH801 on 16 November, further aircraft following at regular intervals.

The number of RAF Canberra squadrons had dwindled to nine by 1971, five of which were home-based special duties units. Two of the remaining four operational squadrons were equipped with PR.9s. These units were 13 Squadron at Luqa, Malta, and 39 Squadron at Wyton, Huntingdonshire. After 12 years in Malta, No.39 had returned home late in 1970 to take the place of the last PR.7 squadron, No.58, which had been disbanded during

The first Canberra T.22 delivered to the Royal Navy was WH801, which later received the unit code number 850. Finish was light grey gloss overall. *(British Aerospace)*

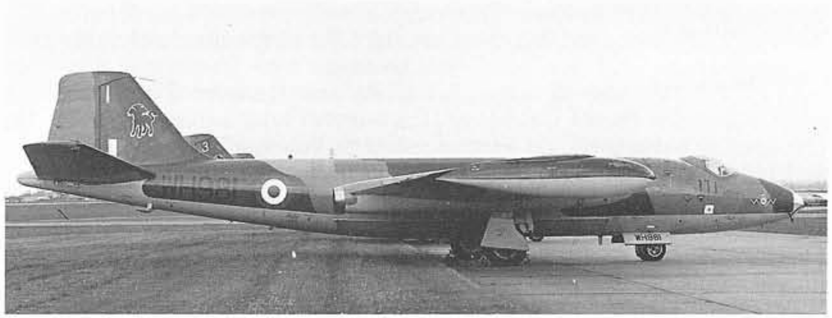
The last RAF Canberras operational in a bomber role were the B(I)8s in RAF Germany. Seen here is XK951 of No.16 Squadron, with the shark's mouth marking that was carried in the final months of service up to disbandment in June 1972. (*MAP*)

the year. The other two operational units were Nos. 3 and 16 Squadrons, both of which had been based in Germany with B(I)8 aircraft for over ten years. Although between 1968 and 1971 the number of Canberra squadrons had been more than halved, the type still equipped over ten per cent of all RAF squadrons in 1971, twenty years after it had first entered service.

The last two RAF squadrons operating B(I)8 interdictors were re-equipped early in 1972. No.3 received Harriers, and Buccaneers were delivered to No.16, both units remaining in Germany. After the withdrawal of the last B(I)8s, the only Canberras remaining in first-line RAF service were the PR.9s of 13 Squadron at Luqa and of 39 Squadron at Wyton.

The target facilities unit, 85 Squadron, had by early 1972 grown in strength to about 25 aircraft. It was then probably the largest squadron in

The last RAF Canberras in front line units were PR.9s. Seen here is XH133 of No.13 Squadron, in the camouflage scheme introduced in about 1968. The squadron disbanded in December 1981. (*MAP*)



Canberra WH981 as an E.15 served with No.98 Squadron from mid-1971. The aircraft had been built in 1955 as a B.6, and was converted to a B.15 in 1962 before becoming an E.15.

the RAF, consisting of B.2s, T.4s and T.19s. Early in 1972, the unit was divided into two parts, one of which continued to be known as 85 Squadron. No.100 Squadron was reformed from the other part. The latter unit had some 12 years previously also operated Canberra B.2s, and its re-establishment with the same type of aircraft was, therefore, a unique event in the history of the RAF. Subsequently, the RAF had six Canberra squadrons in addition to the two PR.9 units (Nos.13 and 39). These six squadrons were all based in the United Kingdom and were engaged in second-line duties. In addition to the radar and interception targets provided by Nos. 85 and 100 Squadrons, towed targets were provided by the TT.18s of 7 Squadron. The remaining three units were all engaged in electronics work. Nos. 51 and 98 Squadrons, with B.6 and E.15 aircraft, were engaged in signals and calibration work, and 360 Squadron with T.17s provided electronic countermeasures training facilities.

South American Canberra purchases continued in February 1973 with an order from Peru placed with Marshalls of Cambridge for eight ex-RAF B(I)8s, the quantity later being increased to eleven. The aircraft were refurbished and modernised, being redesignated B(I)68. Marshalls did most of the work on these aircraft, although all the centre fuselages were structurally refurbished by BAC at Samlesbury. Deliveries to Peru started

The 25th anniversary of the Canberra's first flight was in 1974. It was celebrated at RAF Cottesmore with this gathering of Canberras. The eleven aircraft nearest the camera are (from left to right): E.15 (No.98 Squadron), PR.9 (No.39 Squadron), T.22 (FRADU), B.2 (RRE), PR.9 (RAE), TT.18 (No.7 Squadron), PR.7 (No.13 Squadron), T.19 (No.100 Squadron), B.2 (No.85 Squadron), B.2 (231 OCU), T.17 (No.360 Squadron). (*British Aerospace*)

in March 1975, and the last of the original eight aircraft was despatched in January 1976, with the extra three aircraft following between October 1977 and July 1978.

In 1974 BAC received a contract from Venezuela for the refurbishing and updating of twelve Canberras, the number later being doubled to 24. The aircraft concerned had been supplied to Venezuela new in 1953 (B.2s) and 1957/58 (T.4s and B(I)8s), or refurbished in 1966/67 (B.2s and PR.3s). The updating work was similar to that done on four aircraft some years earlier, the work causing them to become B.82s, PR.83s, T.84s and B(I)88s. The condition of most of the aircraft was such that it was decided that all should be dismantled and air freighted to the United Kingdom, all the initial batch arriving in the later months of 1975.

India obtained further Canberras in 1975 when six T.4s were bought direct from the RAF. The aircraft were in storage at RAF Kemble, and after servicing all were delivered to India between June and September 1975. In India these aircraft were modified by Hindustan Aviation to have target-towing equipment similar to that of the TT.18.

A further refurbishing contract was received by BAC in 1976 as a result of a decision by the RAF that Canberras should be kept in service through the 1980s. The aircraft affected by this decision were termed the 'Long Term Fleet'. BAC's contract initially covered 24 aircraft, later increased to 50. Six different marks of Canberra were included in this total (B.2, T.4, PR.7, E.15, T.17, TT.18). The first aircraft in the programme was WK116, which flew into Samlesbury on 2 June, 1976. The others followed progressively in the period 1977 to 1980.

Although the RAF had decided that the Canberra would stay in service for many more years, the number of squadrons operating the type declined slowly through the 1970s. The four modified B.6s operated by No.51 Squadron had all been withdrawn by mid-1974, although the squadron did not disband, having received Nimrod R.1 aircraft. In December 1975 No.85 Squadron at West Raynham disbanded, passing some of its aircraft to No.100 Squadron which was moving from West Raynham to Marham. No.98 Squadron at Cottesmore disbanded in February 1976, some of its E.15 aircraft also going to No.100 Squadron. This unit thus grew to over 20 aircraft, including B.2s, T.4s, E.15s and T.19s.

Canberra B.2 WK116 of No.100 Squadron arriving at Samlesbury on 2 June, 1976, as the first of the 'Long Term Fleet' aircraft. (*British Aerospace*)

The last RAF Canberras based overseas returned in October 1978, when No.13 Squadron moved its PR.7s from Luqa, Malta, to Wyton. The unit had for a number of years operated both PR.7 and PR.9 aircraft, but by the time of the move to Wyton all the PR.9s had gone to No.39 Squadron, also at Wyton.

Redelivery of the 24 refurbished Venezuelan aircraft started in July 1977 when B.82 1183 left Warton. The others followed in the period to June 1980. Originally two PR.3s were included in the contract, but aircraft 2444 crashed before return to the United Kingdom, so that only one, 2314, was eventually refurbished to PR.83 standard. The total number was thereby reduced from 24 to 23.

The last of the 50 RAF 'Long Term Fleet' aircraft being refurbished at Samlesbury, T.17 WJ630, arrived on 9 December, 1980. By that time 17 aircraft had been redelivered. During 1980 the Royal Navy had decided that four of the Canberras serving with the Fleet Requirements Unit at Yeovilton should be refurbished. The four aircraft, three TT.18s and a T.4, arrived at Samlesbury between February and April 1981. As the number of Canberras in RAF service steadily declined, British Aerospace (as BAC had become) bought 12 aircraft for possible refurbishing and sale overseas. These all arrived at Samlesbury in late 1981, and were placed in storage. The RAF also disposed of two aircraft, B.2 WH666 and T.4 WJ869, to Zimbabwe. These aircraft were supplied direct from RAF Marham, leaving on 25 March, 1981. Zimbabwe (formerly Rhodesia) was at that time still operating a number of Canberras originally received in 1959.

A repeat order for refurbished Canberras was received by British Aerospace (BAe) in 1981 from Argentina. Two aircraft were involved, and they were drawn from the 12 bought by BAe in anticipation of such orders. One aircraft was B.2 WH914 (to be refurbished to B.92 standard), the other was T.4 XH583 (to become a T.94). When refurbishing work was well advanced work was suddenly suspended due to the invasion of the Falkland Islands by Argentina in April 1982. The Argentine Air Force Canberra squadron had nine of the original 12 aircraft available for operations, and they were quickly made ready to attack the British Royal Navy task force which sailed towards the Falklands in response to the invasion. The first sorties against the ships of the task force were on 1 May, in daylight. A flight of three Canberras was intercepted by Sea Harriers operating from the aircraft carrier HMS *Invincible*. One Canberra, B110, was shot down by a Sidewinder missile launched by a Sea Harrier. After this experience the Canberras were restricted to night operations, most of which were against British land forces after they had landed on 21 May. Early on the last day of the war, 14 June, two Canberras bombed their target near Port Stanley from 40,000 ft, but as they were leaving the target area one aircraft, B108, was hit by a Sea Dart missile fired from a British naval vessel, and crashed into the sea. Argentine Canberras flew a total of 35 sorties during the war, and achieved some success, but the loss of the two aircraft clearly showed the vulnerability of the type in a hostile environment.

The fact that by 1982 the Canberra was obsolete in first-line roles, clearly demonstrated in the Falklands war, caused the RAF to withdraw their last two first-line squadrons in 1982. No.13 Squadron, flying PR.7s, disbanded in January; with No. 39 Squadron, equipped with PR.9s,

Seen landing at Wyton in 1982 is Canberra TT.18 WK118 of No.100 Squadron. Upper surfaces are grey and green camouflage; lower surfaces are yellow and black stripes, the standard target-tug marking. (*MAP*)

following in May. Also disbanded was No.7 Squadron at St Mawgan, with TT.18s. Some of the aircraft from Nos.7 and 13 Squadrons were transferred to No.100 Squadron, which moved from Marham to Wyton in January 1982. In July the training unit, 231 OCU, also moved from Marham to Wyton. The result of these changes was that all remaining RAF Canberras were concentrated at Wyton. A total of about 45 aircraft equipped the three units on the station. Largest was No.100 Squadron, with B.2, PR.7, E.15 and TT.18 aircraft, employed in target facilities and calibration work. No.360 Squadron retained its T.17s, used for ECM training; and 231 OCU continued to operate T.4s and a few B.2s. Of the PR.9s from the disbanded No.39 Squadron, five were retained at Wyton to equip a newly formed unit, No.1 Photographic Reconnaissance Unit, which took over the photographic-survey task previously done by No.39 Squadron. Most of the other PR.9s were placed in storage, except for three that were sold to Chile. These were delivered from Wyton on 15 October, 1982, and were not handled by BAe. Chile was a new customer for the Canberra, and brought the number of countries that had bought the type to 15.

The four RAF Canberra units that by the end of 1982 were at Wyton were all intended to remain basically unchanged until at least the late 1980s, and it was to equip these units that the 'Long Term Fleet' aircraft were being refurbished at Samlesbury. The last of these was WJ630, a T.17 that was redelivered in May 1982. The four extra aircraft being refurbished for the Royal Navy were all completed by the end of the year. During July 1982 the first of seven Canberras to be refurbished for Ministry of Defence research establishments arrived at Samlesbury. This aircraft, the T.4 WJ992, arrived by road in sections, except for the nose fuselage which was retained at RAE Bedford. All of the nose fuselages were to be refurbished by the RAE, who would also re-assemble and flight test the complete aircraft. The seven MoD aircraft were to be handled at the rate of about two a year; this low rate, plus the addition of two further aircraft, stretched the MoD refurbishment programme into 1988.

After a high level of refurbishing work throughout the 1970s and up to the end of 1982, BAe Samlesbury had by 1983 almost run out of Canberra work, a unique situation, as there had always been a large volume of

Canberra work in the factory since the start of production in 1949. Indeed, some company employees had spent virtually the whole of their working careers on the type. Continuity of experience is very important for efficient working, and BAe was keen to obtain further Canberra work to maintain continuity. Such work was obtained in the form of a contract to perform major servicing on 37 RAF Canberras, the first arriving at Samlesbury in June 1984, with the whole programme being scheduled to be completed by about the end of 1987. Included in the contract were a number of T.17s, which were to be fitted with updated avionic equipment necessary for their ECM training role. The first of these T.17s was WD955, built in 1951, and thus the RAF's oldest active aircraft of any type. On its return to No.360 Squadron from Samlesbury it was 36 years old; it would appear to have a reasonable chance of reaching 45 years in service, perhaps even 50! Several of the MoD aircraft being refurbished might reach 50 years; certainly they should reach the year 2000, when they will be about 45 years old.

The achievements of the Canberra can be divided into three broad fields. First, the aircraft equipped a large part of the RAF for about 20 years, being the Service's first jet bomber, and its only jet bomber for four years. The wide variety of second-line roles fulfilled by the Canberra made the type particularly valuable to the RAF. Second, the Canberra made important contributions to numerous research and development programmes, in Britain and abroad. This work covered many fields, and was made possible by the great versatility of the type. Third, the Canberra's success in the export market not only produced valuable business for English Electric and BAC but also made a useful contribution to British exports in general. The total number of Canberras built was 1,376, of which 925 (67 per cent) were produced in the United Kingdom, and 451 were licence-built overseas. Martin output under licence in the USA totalled 403, and the Australian Government Aircraft Factory produced the remaining 48 licence-built aircraft. New Canberras were built in 21 versions, the most numerous of which was the B.2, 418 being produced. Of the 925 aircraft manufactured in Britain, 631 (68 per cent) were built by English Electric, 144 (16 per cent) by Short Bros & Harland, and 75 (8 per cent) each by Avro and Handley Page. 782 of the British-built aircraft were

Representative of numerous preserved Canberras is B.2 WD935, the oldest surviving Canberra. It is an exhibit in the RAF St Athan Museum, seen here in 1982 after being repainted in the markings of No.10 Squadron. (*MAP*)

Canberra B.2, PR.3, T.4, B.6, PR.7, B(I)8 and PR.9. Powerplant: B.2, PR.3, T.4, two 6,500 lb st Rolls-Royce Avon RA.3 Mk 101; B.6, PR.7, B(I)8, two 7,500 lb st Rolls-Royce Avon RA.7 Mk 109; PR.9, two 10,050 lb st Rolls-Royce Avon RA.24 Mk 206

	B.2	PR.3	T.4	B.6	PR.7	B(I)8	PR.9
Span	63ft 11½in	63ft 11½in	63ft 11½in	63ft 11½in	63ft 11½in	63ft 11½in	69ft 5in
Length	65ft 6in	66ft 8in	65ft 6in	65ft 6in	66ft 8in	65ft 6in	66ft 8in
Height	15ft 7in	15ft 7in	15ft 7in	15ft 7in	15ft 7in	15ft 7in	15ft 7in
Wing area	960sq ft	960sq ft	960sq ft	960sq ft	960sq ft	960sq ft	1,045sq ft
Empty weight	22,200lb	22,780lb	21,800lb	21,680lb	21,700lb	23,170lb	—
Normal loaded weight	40,500lb	40,000lb	33,000lb	51,450lb	49,000lb	51,000lb	—
Maximum loaded weight	46,000lb	46,000lb	38,000lb	55,000lb	55,000lb	56,250lb	57,500lb
Maximum speed at sea level	518mph	518mph	518mph	518mph	518mph	510mph	—
Maximum speed at high altitude	570mph	570mph	570mph	580mph	580mph	560mph	560mph
Initial rate of climb	3,800ft/min	3,800ft/min	4,300ft/min	3,500ft/min	3,600ft/min	3,600ft/min	—
Maximum operational altitude	48,000ft	48,000ft	48,000ft	48,000ft	48,000ft	48,000ft	70,000ft*
Normal maximum range	2,660 miles	3,585 miles	3,110 miles	3,400 miles	4,340 miles	3,400 miles	4,000 miles*
Normal maximum fuel	1,865 Imp gal	2,405 Imp gal	1,865 Imp gal	2,765 Imp gal	3,305 Imp gal	2,765 Imp gal	3,305 Imp gal

*Approximate figures.

Armament and stores carried:

B.2, B.6: Up to 6,000 lb of stores all carried internally; typically including six 1,000 lb bombs, or one 4,000 lb and two 1,000 lb bombs, or eight 500 lb bombs, or various other combinations including practice bombs.

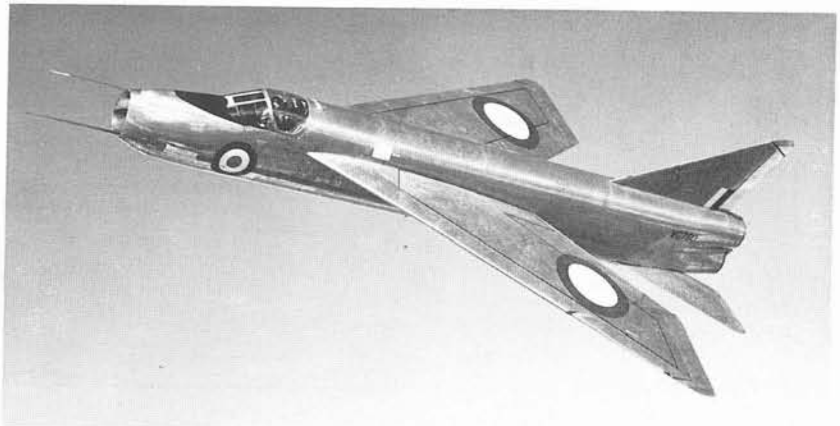
PR.3, PR.7, PR.9: Flares and photoflashes carried internally. T.4: No armament.

B(I)8: Bomber role—internal armament as B.2 and B.6. Interdictor role—gun pack with four 20mm Hispano cannon in bomb-bay, also two 1,000 lb bombs or flares; up to 2,000 lb of stores carried on pylons, typically including two 1,000 lb bombs or two rocket launchers each with thirty-seven 2 in rockets, or flares.

Other marks: All are derived from the basic marks covered above, specification differences being as described in the text.

supplied to the RAF, the remaining 143 being exported. All of the 143 new Canberras exported from Britain came from English Electric production, and represented 23 per cent of the company's output. The total value of these exports was £47 million.

It is unlikely that even Petter could have anticipated the outstanding success his aircraft was to achieve, and the Canberra was undoubtedly his most inspired design. The type re-established English Electric in the field of aircraft design, and was responsible for making the company's name as well known in the aircraft industry as it was in the electrical world.

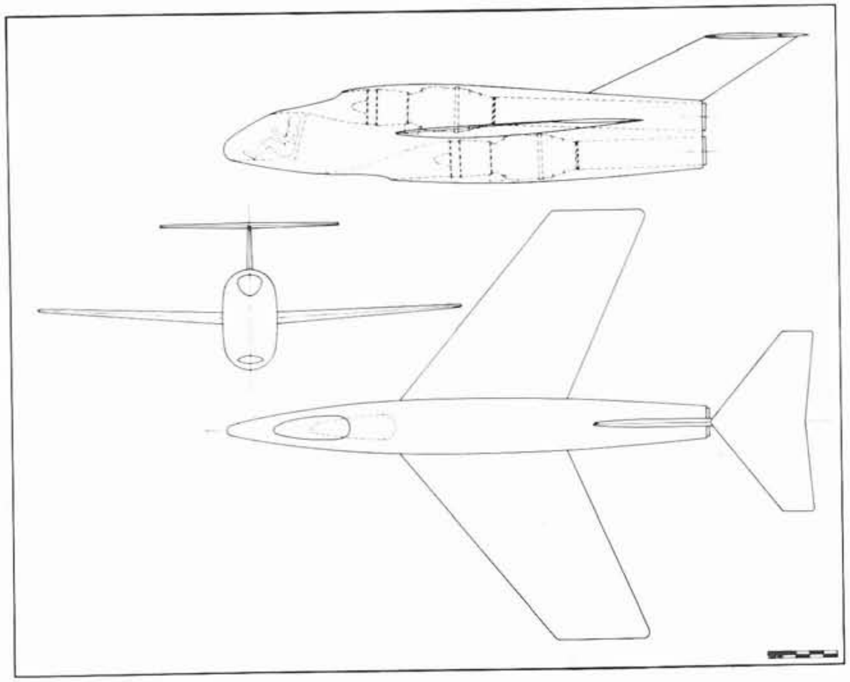


A fine portrait of the P.1A prototype WG760 flown by Roland Beamont. (*British Aerospace*)

English Electric Lightning

In February 1946, an ambitious British attempt to produce a supersonic aircraft, the Miles M.52, was summarily cancelled. A number of factors, both technical and political, contributed to the cancellation. By the end of 1947, however, a new supersonic research programme was to be launched with the issue of Experimental Requirement 103. This requirement called for an aircraft to explore the transonic and low supersonic speed ranges and had been formulated after discussions between the Ministry of Supply and the aircraft industry.

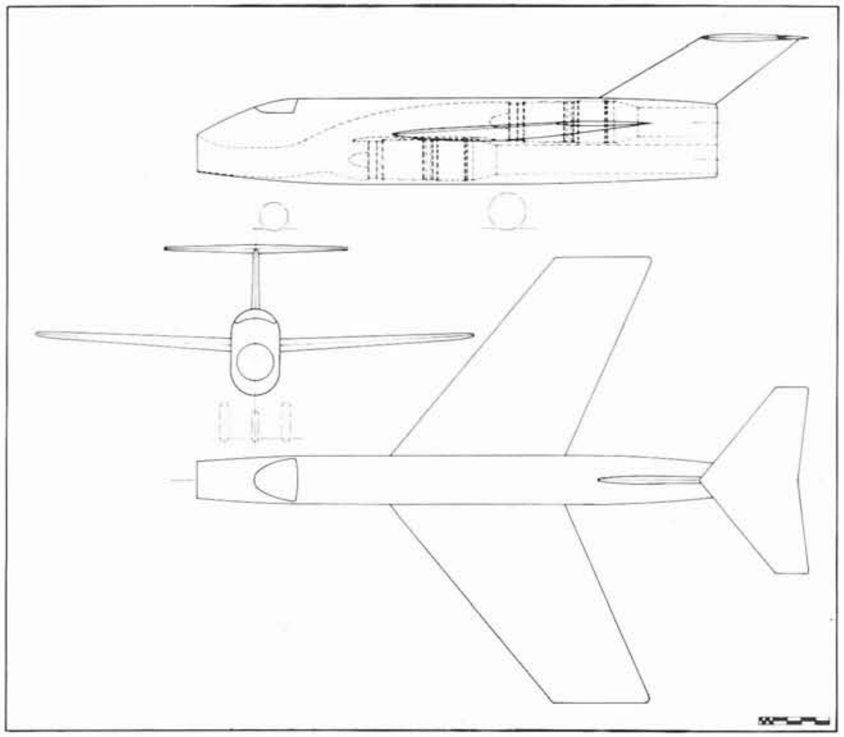
English Electric was among the aircraft companies which investigated an aircraft to meet ER 103, the initial design studies being made in the summer of 1948. They were the foundation for a line of research and development which was to lead to the Lightning. When Petter and his team began their work, the data available on transonic and supersonic aerodynamics was very limited, a fact that is apparent in the earliest project drawings. Most of the early aerodynamic investigations were theoretical, and the work in this field, undertaken by R.F. Creasey, had to combine basic research with aircraft design. In spite of the shortage of basic data,



English Electric P.1 (July 1948).

the important features of the aircraft's layout were settled soon after the earliest sketches had been made in July 1948. Most of these features were to remain unchanged throughout the development of the design. Twin engines were selected in order to provide sufficient thrust to achieve the required supersonic speed and to obtain satisfactory manoeuvring performance. To minimise drag, the engines were installed in the fuselage in a staggered layout, one being further forward and below the other. In addition, this engine arrangement eliminated asymmetric thrust problems due to single engine failure. Several types of intake were considered, the preferred locations being either at the nose, or in the fuselage sides. The choice was made in favour of a nose intake, as it was expected to prove easier to develop. The chosen wing planform was sharply swept and was slightly tapered. The mid-wing location was selected to minimise interference drag between the wing and fuselage and to allow structural continuity of the wing. The intake duct to the upper engine passed over the wing, whilst the lower engine bay was situated immediately below it. The fin was sharply swept, and carried a tailplane of delta planform at its tip. The stowage of the main undercarriage, as expected, presented some difficulties owing to the volume required in what was a closely-tailored airframe.

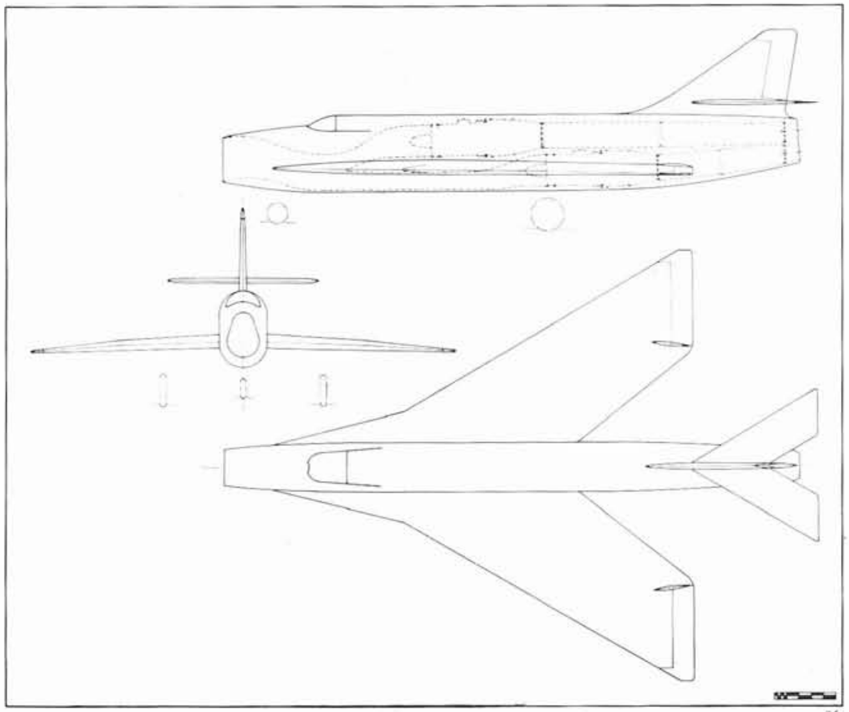
On 3 August, 1948, the Ministry of Supply awarded English Electric a contract for a design study based on ER 103. Three months later, on 1 November, 1948, the company formally submitted its proposal to the



English Electric P.1 (July 1948).

Ministry. In January 1949, English Electric introduced its project numbering system, and the transonic research aircraft submitted to ER 103 was designated P.1. At the end of March, the Ministry of Supply notified English Electric that preliminary approval had been granted to the company to proceed with design work on the P.1, and to make wind-tunnel models and build a mock-up. The formal contract for this work was received on 12 May, 1949, the day before the Canberra made its first flight.

The basic design that had been evolved during 1948 was developed further during 1949. During the year the low-speed and high subsonic speed wind-tunnels at Warton were used to evaluate the aerodynamics of the design, and as a result a number of alterations were made. The tailplane, which had been mounted at the top of the fin, was moved first to the base of the fin and then to the bottom of the rear fuselage. The planform of the tailplane was also changed, being made similar to that of the wing, instead of the earlier delta shape. The sweep of the wing leading-edge was increased to 60 degrees, this angle ensuring that the vortex lift produced by the very highly swept wings would be fully developed. The wingtips were cut off normal to the direction of flight to provide a location for the ailerons where they would be most effective. The main undercarriage layout finally chosen had the wheels retracting away from the fuselage into the wings. To overcome the geometrical problem introduced by the highly



English Electric P.1 (February 1949).

swept wings, a skewed pivot was designed for the main undercarriage legs. The P.1 undercarriage was one of the first to have such a pivot, although this feature was later to be used in the design of many undercarriages. A result of the engine air intake configuration was that the nosewheel had to be rotated through 90 degrees as it was retracted into the lower front fuselage, where it was stowed flat below the intake. One of the most distinctive features of the P.1 was the pear-like shape of the intake. Originally round, the intake shape was modified to improve the pilot's visibility over the nose.

By the end of 1949 all important aspects of the P.1's design had been frozen. Two features of the design, in particular, were considered by many experts outside English Electric to be controversial: these were the very highly swept thin wing, and the mounting of the tailplane at the bottom of the rear fuselage. However, on the basis of their wind-tunnel testing at subsonic speeds, and their theoretical supersonic work, the English Electric design team was confident that these features were the correct choice to achieve its particular aims. Nevertheless, the basic design decisions had had to be made without any experience of supersonic flying, and with no first-hand experience of supersonic wind-tunnel work. The team did, however, have the benefit of some early theories which later came to be known as the Area Rule. Concerned with the optimisation of the

distribution of cross-sectional area in a supersonic aircraft, these theories were applied to the P.1 in the early stages of design. The designers found that the highly swept wing and tailplane geometry conformed well to the principles of the theories, so that complex shaping of the fuselage was not necessary. Although the Area Rule theories supported the design team's decisions, the degree of courage needed in freezing the design in 1949 can only be fully appreciated in retrospect. At that time, high-speed aircraft built in Britain and abroad were experiencing serious drag, buffeting, and losses of stability and control as they flew just below the speed of sound.

The ultimate object of supersonic research in Britain was to produce a supersonic fighter. The first positive step towards this goal was taken in September 1949, when the Ministry of Supply circulated a first draft of specification F23/49, which called for a supersonic day fighter. In the following month, English Electric made minor amendments to its P.1 design study to meet the requirements of F23/49. This was not the first consideration of the P.1 for this role; the design team had forseen this possibility at the outset of the project. During 1950, specification F23/49 was amended several times as the detail requirements for the àircraft were decided. The F23/49 fighter was to be able to fly at supersonic speed in level flight without the use of reheat and was to make interceptions by day under ground control, the radar to be carried in the aircraft being used only for ranging the two guns, which were to be the standard armament.

In February 1950, Petter resigned his position as chief engineer of English Electric's Aircraft Division. His successor was F.W. Page, who had previously been assistant chief designer. Page was to have overall responsibility for the detail design of the P.1, and for guiding the aircraft through all of the difficult and complex stages between detail design and entry into service as the Lightning.

The first major milestone in the development of the P.1 was reached on 1 April, 1950, when English Electric received a contract for the construction of three airframes, two of which were to be completed as flying prototypes, with the third being intended for static test work. In view of the unconventional layout chosen for the P.1, the Ministry decided that a research aircraft should be built to investigate the low-speed handling characteristics of the design. The company chosen to build this aircraft was Short Bros & Harland of Belfast, who designated it the SB.5. Effectively a flying scale-model of the P.1, the SB.5 was to have the same highly swept wing and low-mounted tailplane, and also the same nose air-intake and wingtip ailerons. By using the SB.5 for low-speed investigations before the P.1 flew, it was hoped that the latter could be made trouble-free at low speeds. The elimination of such potential problems was particularly important, in order to avoid delaying the supersonic research work with the P.1. As already mentioned, English Electric had chosen a wing sweep angle of 60 degrees and a low-mounted tailplane for the P.1, but experts at the RAE, Farnborough, favoured a sweep angle of 50 degrees and a high-mounted tailplane. In order to check the relative merits of these different configurations, the SB.5 was designed so that the wing could be fixed at either 50 or 60 degrees of sweep, and the tailplane could be mounted at the top of the fin or under the rear fuselage. So as to obtain further information on the effects of wing sweep, a third wing position, at 69 degrees sweep, was also to be catered for in the design.

Detail design work for the P.1 was well under way in 1950, the design team at Warton then being about 100 strong. In July, the first supersonic wind-tunnel tests were made at Warton, the tunnel used being the modified jet-powered subsonic tunnel first run the previous year. The layout of the aircraft proceeded in parallel with aerodynamic development. The fuselage was to be built in three sections. The front fuselage contained the pressurised cockpit, part of the intake duct, the nosewheel bay and two equipment bays. A Martin Baker Mk 3 ejector-seat was to be provided for the pilot. Both of the Armstrong Siddeley Sapphire AS.Sa.5 turbojets were housed in the centre fuselage, and together with their intake ducts and jet-pipes, occupied nearly all of its volume. Initially, reheat jetpipes were not fitted, and without reheat the engines produced 8,100 lb of thrust. The centre-section of the wing torsion-box passed through the fuselage at mid-height. Immediately forward of the wing centre-section, the common intake duct to both engines split into two separate ducts. The lower of these carried air directly to the No.1 engine, situated below the wing centre-section. The upper duct carried air over the centre-section to the No.2 engine, which was mounted in the upper centre fuselage behind the centre-section. The triangular-shaped fin and the tailplanes, which were of similar planform to the wings, were attached at the rear of the centre fuselage, where a brake parachute was also installed in a small compartment in its underside. The rear fuselage was little more than a fairing round the ends of the jetpipes. However, part of it contained the air-brakes, which hinged rearwards from the sides of the fuselage.

The wings were joined on the aircraft centre-line and assembled to the fuselage as one unit. Each wing torsion-box contained an integral fuel tank and the main undercarriage bay. The leading-edge of the wing was eventually to incorporate the features tested on the SB.5, namely the hinged flap at the wing root and the small notch near the wingtip. The wing trailing-edge was occupied by split flaps, and the ailerons were mounted on the wingtips, normal to the airflow.

By early 1952, the Ministry was considering the need to build prototypes of the F23/49 fighter development of the P.1. This aircraft would incorporate significant design changes from the P.1, in particular more powerful engines would be needed, and radar would have to be installed. In June, English Electric were informed that the Ministry did intend to order prototypes of the F23/49 fighter, and the company began to consider the necessary design changes. To distinguish the P.1 research aircraft from the F23/49 fighter, the former was renumbered P.1A, and the latter P.1B.

The changes required for the conversion of the P.1A to the P.1B were decided by July 1952 and mainly concerned the front fuselage of the aircraft. The pear-shaped pitot intake of the P.1A was replaced by a circular, double-shock intake system to cater for higher supersonic speeds. The shock body, a fixed bullet-shaped fairing mounted in the centre of the intake, provided the ideal place to mount the radar. This fairing was supported by a pylon built up from the lower surface of the intake and was conveniently placed for the nosewheel to be retracted forwards into it, thus avoiding the complicated retraction geometry of the P.1A's nose undercarriage. The canopy of the P.1A was replaced by a bubble-type canopy. Apart from the front fuselage, the layout of the P.1B was similar to that of

the P.1A. In order to be able to achieve higher supersonic speeds than the P.1A, the P.1B was to have two engines of considerably greater thrust, which could be further increased by the use of reheat. Changes were made accordingly to accommodate the larger engines and reheat jetpipes and to increase the internal fuel capacity. In addition, provision was made for the installation of the wide range of equipment needed in the fighter aircraft.

The heart of the P.1B's weapon system was to be AIRPASS, an abbreviation of Airborne Interception Radar and Pilot Attack Sight System. Other important parts of the weapon system were a computer and the autopilot. In a typical interception mission, the pilot would be guided by ground radar to the general area of the target. The AIRPASS radar would search for the target, and when it was located would lock-on and track it. The computer would then calculate the best interception course, which was presented to the pilot by means of the attack sight display. The pilot was also told when to fire the Firestreak missiles, with which the P.1B was to be armed, by means of a signal on the display. The whole procedure could be performed without any visual contact with the target, but if this (visual contact) was available, then conventional sighting methods could be used if desired. In the case when a non-visual approach to the target was made, an automatic device ensured disengagement before there was danger of collision.

The standard armament of the early P.1Bs was to be two 30 mm Aden cannon, built in to the upper forward fuselage, and two de Havilland Firestreak (initially known as Blue Jay) air-to-air missiles. These were to be carried on pylons mounted on the sides of a detachable pack which formed part of the lower forward fuselage. Alternative packs were to be fitted, which offered the choice of two extra Aden cannon, or forty-eight 2 in spin-stabilised rockets.

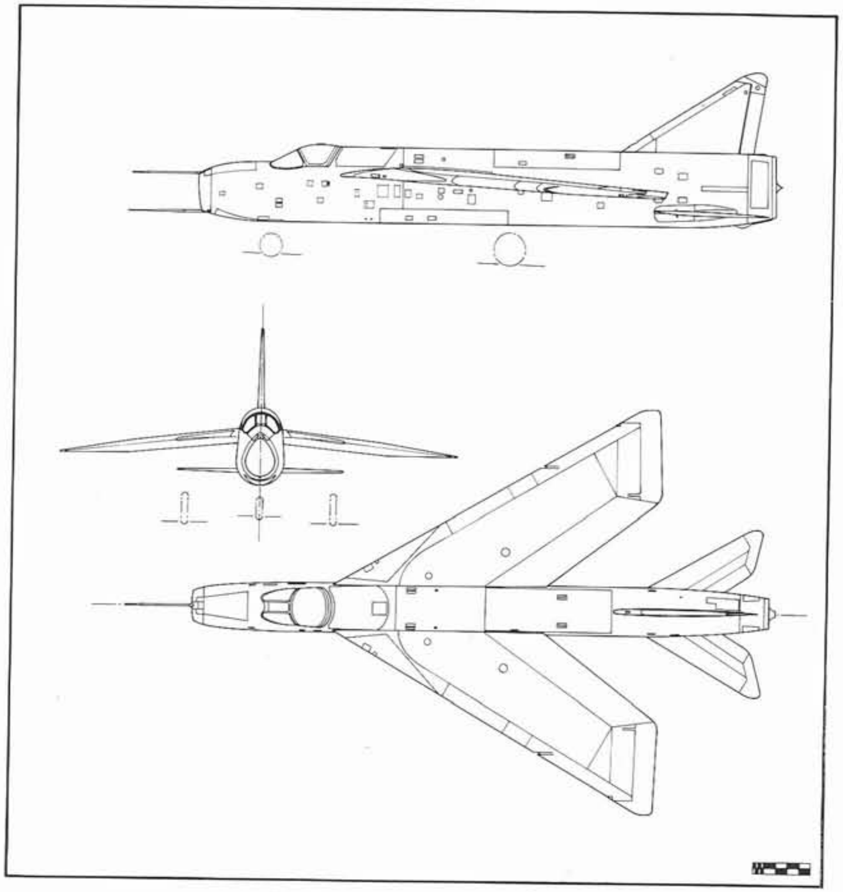
The Short SB.5, WG768, flew for the first time on 2 December, 1952, at Boscombe Down. When the first photographs of WG768 were published shortly afterwards, they revealed such a distinctive design that speculation was aroused concerning the identity of the new aircraft for which the SB.5 would conduct research. Although the existence of the P.1 project was supposed to be a closely guarded secret, at least one magazine reported that the SB.5 was the forerunner of a fighter being built by English Electric. The first flight of WG768 was made with the wings at 50 degrees sweep and the tailplane on top of the fin, and this configuration was retained for the first series of test flights. In August 1953, the SB.5 began its second series of test flights, for which the wing sweep was increased to 60 degrees and the tailplane was retained at the top of the fin. During August, Beamont, who as English Electric's chief test pilot would be in charge of P.1 test flying, made his first flight in the SB.5. In January 1954, the configuration of the SB.5 was changed again, the tailplane being moved to the bottom of the rear fuselage. In addition, the full-span leading-edge flaps used in the two previous configurations were modified so that only the inboard segments at the wing roots could be deflected. These flaps were expected to delay the stall and improve longitudinal stability. The layout was now the same as that of the P.1, so that the results of flight tests were of greater interest to English Electric than had previously been the case. Beamont flew WG768 twenty-two times between February and May 1954, gaining experience of the type of handling characteristics he could expect

from the P.1. When flown in the first two configurations, the SB.5 had generally proved to be unsatisfactory. However, the third configuration, which was similar to that of the P.1, was found to have good handling characteristics except at just above landing speed, when the pilot experienced uneven aileron control forces. The source of the problem was found to be uneven airflow over the ailerons, due to the wing's leading-edge vortices. Initially, a wing fence was considered as a solution to the problem, but a small notch in the wing leading-edge was found to be equally effective and incurred a smaller drag penalty than the wing fence. (The handling difficulty cured by the notch was only felt by the pilot because the ailerons of the SB.5 were unpowered; the problem was therefore not relevant to the P.1 which had fully powered flying controls. However, the leading-edge notch was retained as a P.1 feature, as it was found to be beneficial, but for an entirely different reason than on the SB.5). The principle of vortex lift was verified by the SB.5, and English Electric's basic layout of the P.1 was shown to be correct. Thus the SB.5 had served its purpose in convincing the RAE; English Electric had always regarded the aircraft as being rather unnecessary.

The formal contract for the P.1B was placed on 5 August, 1953, over a year after the Ministry had notified English Electric that prototypes were to be ordered, and covered three aircraft. By 1953, the P.1As were regarded mainly as preliminary prototypes for the P.1B, and not as pure research aircraft, as had originally been the case. Following the award of the contract for the P.1B fighter prototypes, the Ministry began to consider the eventual need for a two-seat trainer variant of the fighter. An operational requirement for such an aircraft was issued, and in October 1953, English Electric started work on a design study of a modified P.1B to meet the requirement.

On 26 February, 1954, English Electric received a contract for twenty P.1B development aircraft. The ordering of these marked a change in the approach to the development of advanced military aircraft, for only prototypes had been used in the development of previous British types in this category. There were two basic reasons for this change in policy. First, the P.1B would require considerably more flight testing because of its supersonic performance, and second, the equipment and systems to be fitted were necessarily more complex, which again would increase the time needed for development. If this work was to be done within a reasonably short period, numerous aircraft would have to be employed in development flying. The availability of 20 development and three prototype aircraft would enable English Electric to allocate each to a particular field of work, such as performance, handling, engines, weapon system, radar and autopilot. Two months after receiving the development aircraft contract, the company obtained approval to begin design work for the first mark of production aircraft.

The summer of 1954 saw the powered flying controls of the P.1 being tested on a rig at Warton. This rig simulated the installation of all the aircraft's controls, and included a dummy cockpit with pilot's control column and rudder pedals. These enabled Beamont to assess the feel of the controls in various flight conditions and also enabled any problem areas to be rectified. This rig was probably the first of its type in Britain: in later years similar rigs were built for most new aircraft types. Beamont gained



English Electric P.1A (WG760).

further experience applicable to his forthcoming P.1 flying in a series of flights made in Hawker Hunters in the early summer of 1954. Each flight included a dive to supersonic speed, providing him with further experience of transonic flight.

The first P.1A prototype, WG760, was completed in May 1954, and taken to the Ministry of Supply aerodrome at Boscombe Down in Hampshire. This site had been selected for the early test flights in preference to Warton because its runways were longer and it had generally better facilities. Warton was at that time only in the early stages of its development as a sophisticated flight-test centre. In the weeks following WG760's arrival at Boscombe Down, many of the design and engineering team from Warton spent long hours working on the aircraft, undertaking the final preparations and checks necessary before the start of flight testing. Engine runs were made during the first half of July and on 24 July

the first taxi-ing trials were made. Two days later, three further taxi runs were made, the brake parachute being streamed at the end of each run. No problems were encountered and the decision was made to attempt a short hop above the runway later the same day. At minimum weight, WG760 was quickly airborne and flew for 500 yards at a height of 10 feet and speed of 140 knots, after which Beamont landed and brought the aircraft to rest before reaching the end of the runway. Braking tests were made on 2 August, and afterwards WG760 was prepared for its first flight which took place two days later. After take-off on the first flight, Beamont gradually took WG760 higher and faster up to a maximum speed of 440 knots. A preliminary assessment of handling characteristics was made at this speed, with satisfactory results. Beamont brought WG760 in for a safe landing at 160 knots, after being airborne for 40 minutes. The flight was considered to have been completely successful, Beamont having been particularly impressed by the response of the aircraft in handling manoeuvres.

The day after the first flight, WG760 flew again, further handling assessments being made at low altitudes. On 11 August, the third flight was made, which lasted 50 minutes. Beamont took WG760 to a height of 30,000 ft and a level high-speed run was made at an indicated speed of Mach 0.98. When the records from the flight test instrumentation were analysed after the flight, the actual Mach number achieved in the level run was found to have been 1.02. WG760 thus became the first turbojet aircraft to fly faster than sound in steady level flight. Two days later, WG760 flew two deliberate level supersonic runs up to Mach 1.08 and reached a maximum altitude of 40,000 ft. A further nine flights were made before the end of August, one of these including a manoeuvre at supersonic speed. The progress achieved during the month resulted in the whole of the initial flight-test programme being satisfactorily completed. The aircraft had also shown its ability to climb to 30,000 ft in four minutes—at that time a spectacular performance. Supersonic speed and handling had presented no problems, and landings within the specified distance had been demonstrated.

Regular test flights by WG760 from Boscombe Down continued during September 1954, until, on 23 September, Beamont flew the aircraft back to Warton. This was the twenty-seventh flight, and subsequent test flying was

The first published photograph of the P.1A shows WG760 at Boscombe Down in July 1954. (*British Aerospace*)

The P.1A WG760 landing at Warton with the aid of the braking parachute. This is one of the very few photographs showing the leading-edge flaps in use. (*British Aerospace*)

undertaken from Warton. By the end of 1954, over 50 flights had been made, and a Mach number of 1.22 had been achieved. The P.1A had been designed for a maximum speed of Mach 1.2, at which its handling characteristics were found to be excellent. The aircraft was found to be capable of speeds appreciably above Mach 1.2, but at higher Mach numbers insufficient directional stability was experienced in supersonic manoeuvres, indicating that a larger fin would be required for the faster P.1B.

The flight testing of WG760 continued to progress smoothly in the early months of 1955, and by March the aircraft was ready for an initial assessment at the A & AEE, Boscombe Down, where it spent most of March, and then returned to Warton to continue test flying. During the summer, the public was allowed to see a little more of the P.1A. The first air-to-air photograph was published, and on 7 July, WG760 took part in a display at Farnborough to mark the Golden Jubilee of the RAE. (The P.1A had not been allowed to appear at the 1954 air show for security reasons and to avoid interrupting the flight-test programme.)

The second P.1A, WG763, made its first flight on 18 July, 1955. Again Beamont was the pilot, but on this occasion the flight was made from Warton. WG763 was a step nearer to the final P.1B fighter standard than WG760, as it had a more complete equipment fit. Provision was made for

The second P.1A, WG763, seen at Warton with the ventral fuel tank fitted. The nose air-intake is closed by a cover. (*British Aerospace*)

a 250 Imp gal external fuel tank to be carried under the centre fuselage in the form of an elegant fairing, and a pair of 30 mm Aden cannon was installed in the front fuselage. The guns were mounted on each side of the cockpit, with the blast-tubes positioned above the intake. The hinged flaps at the wing-root leading-edges had been found to be unjustified on WG760, and were therefore locked in position on WG763. They were omitted on later aircraft. WG760 was to be used mainly for handling and performance work and WG763 for investigating structural and armament aspects of the design. However, before being committed to development flying, WG763 made the first appearance of the P.1 at the Farnborough air show, in September 1955.

On returning to Warton, WG763 began flight trials with the under-fuselage fuel tank, which was first carried in flight on 7 October. After jettison trials had been completed, the tank was normally carried on most test flights, enabling a useful increase in test flight duration to be achieved. The tank was found not to impair performance.

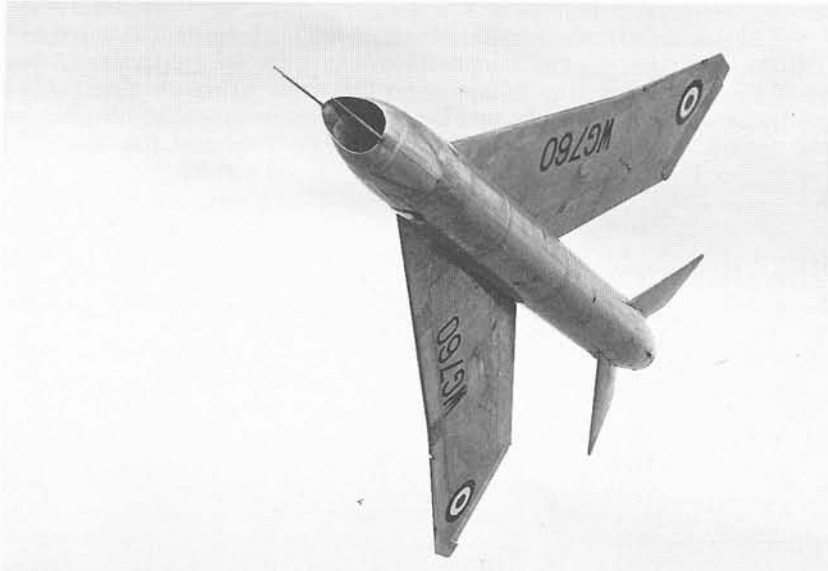
Early in 1956, WG760 was used for the first performance assessments with reheated engine thrust. The first flight with reheat was made on 31 January. The reheated Sapphire engines used were specially developed for the P.1A. In order to minimise the possibility of mechanical problems with the nozzles, they were made fixed-area, being optimised for the reheat condition. Thrust in reheat was 10,300 lb, but as a result of the fixed-area nozzles, thrust without reheat was only about 4,200 lb instead of the normal 8,100 lb.

With two P.1As flying, and the prospect of the P.1B prototypes and development aircraft to come, more pilots were needed and Desmond de Villiers and Peter Hillwood, who had both been engaged in Canberra test flying, joined the flight-test programme. In 1955 and 1956 three incidents occurred which were distinctly uncomfortable for the pilots involved. During a test flight in August 1955, Beamont was startled to find that the canopy had separated from the aircraft. The incident occurred at an indicated speed of 575 kts, and Beamont was to remark that it felt like a 'persistent explosion'. In addition, glass fibre insulation blankets in the cockpit started to disintegrate, and debris from these got into the pilot's eyes. Beamont, however, managed to keep control and landed without further damage to the aircraft or injury to himself. Six months later, de Villiers had a similar experience when flying at 20,000 ft. As in the first incident, the aircraft was landed safely and the pilot was unhurt. Despite actions taken to determine the cause of the incidents and prevent a recurrence, a third canopy was lost in August 1956. In addition to the embarrassment caused to English Electric, this third incident was potentially more dangerous for the pilot and the aircraft, as it occurred at supersonic speed. The unfortunate pilot was again de Villiers, who, in spite of losing his helmet, suffered only shock and managed to land the aircraft safely. The subsequent investigation eventually discovered that under certain conditions unexpected structural deflections could occur which allowed the canopy locking mechanism to become disengaged. Air pressure then lifted the canopy from the aircraft.

In the meantime, the three P.1B prototypes were being assembled at Strand Road. Manufacture of the 20 development aircraft had also started, and preparations were being made too for the construction of the first

The first P.1B, XA847, during engine running trials. It was common practice to run with an engine hatch not fitted. (*British Aerospace*)

batch of production aircraft. Approval for material and tooling purchase had been received at the end of 1955, with the full production contract, for fifty Mk 1 aircraft, following in November 1956. At about the same time, approval was given for materials to be ordered for a second production batch. The studies of a two-seat trainer version, started late in 1953, had by 1956 reached an advanced stage. In May, a contract was received for the design and construction of two prototypes, which were to have the designation T.Mk 4. (The Mk 2 and Mk 3 aircraft were to be developments of the F.Mk 1 fighter). Detail design work peculiar to the Mk 4 was done by English Electric's Acton design office.



The first P.1A WG760, flying with extended cambered wing leading edges, February 1957. (*British Aerospace*)

The first P.1B prototype was nearing completion when the 1957 Defence White Paper was published. In addition to detailing British defence expenditure for the coming year, the White Paper also outlined the Government's long-term policy regarding military aircraft, particularly fighters. The central themes of the new policy were that guided missiles could perform the functions of most combat aircraft with greater efficiency, and that manned aircraft would become unacceptably vulnerable to defensive guided missiles. These philosophies were to influence profoundly British military aircraft programmes for many years. The immediate result of the White Paper was that the RAF's fighter squadrons were substantially reduced in number, many fighters were cancelled, and the development of several fighter and bomber aircraft types was terminated. The P.1B was one of the few new aircraft to escape cancellation, but the cut-back of RAF fighter strength considerably reduced the size of potential orders. The new emphasis on missiles led to the P.1B being widely referred to as 'the RAF's last manned fighter'. An unfortunate side-effect of the British move away from the manned fighter was to be felt some years later. In the late 1950s and early 1960s, when a number of overseas countries were purchasing fighter aircraft, the British policy favouring missiles was a significant factor behind the lack of success in exporting the P.1B.

In February 1957, WG760 started to fly with a cambered wing leading-edge, which also slightly increased the chord towards the wingtip. The modified wing produced useful increments in lift, and improved the pitch-up characteristics of the aircraft, as well as bringing handling benefits in the landing condition. The cambered leading-edge did, however, increase acceleration times to high supersonic speeds, and it was not fitted as a standard feature at that time.

On 11 April, 1957, the number of test flights made by the P.1As reached 500, the supersonic part of these representing by far the greater proportion of all supersonic flying in Britain up to that time. As the development of the Lightning proceeded, the two P.1As were to contribute less and less to the project. Accordingly they were withdrawn from test flying, and in September 1962 both aircraft left Warton. WG760 was handed over to the RAF technical training school at Weeton, near Warton, and WG763 was transferred to the RAE at Bedford, where it was used for supersonic research flying. In the course of this work Mach 1.53 was achieved, this being the highest speed ever reached by either P.1A. By 1967, both aircraft had found their way to the RAF training college at Henlow for preservation.

By early 1957, the first P.1B, XA847, was being prepared for flight. Compared with the P.1A, the most obvious differences were the circular air intake and conical centrebody in the nose, and also the bubble-type canopy which was faired into a spine on the upper fuselage. Less apparent were the changes made to the rear fuselage around the reheat nozzles of the two Rolls-Royce RA.24R turbojets. Each engine could produce 11,250 lb of thrust, which could be increased with full reheat to 14,430 lb. The reheat thrust increment was variable through four settings up to the maximum. The changes to the nozzle resulted in the airbrakes being re-positioned on the upper rear fuselage, close to the fin's leading-edge. The split flaps of the P.1A were replaced by simple flaps, which were capacious enough to hold

useful quantities of fuel. XA847 began engine running in mid-March 1957, and the first flight was made on 4 April by Beamont. During the 24 minute flight from Warton, a speed of Mach 1.2 was reached and handling was found to be entirely satisfactory. XA847 was intended mainly for performance and handling assessment, which progressed smoothly and quickly. By July, English Electric was able to announce that the world air speed record had been exceeded. The actual speed achieved was not disclosed, but the record at that time stood at 1,132 mph or Mach 1.72. The initial service flight clearance to Mach 1.7 was completed in about two months and 35 flights. In September, Beamont made several demonstration flights in XA847 at the Farnborough air show, the combination of aircraft performance and piloting skill producing some spectacular displays.

The primary armament of the P.1B in service was to be the de Havilland Firestreak infra-red guided missile, and in the autumn of 1957, XA847 was flying fitted with dummy missiles. By November, the aircraft was ready for an initial official assessment by the A & AEE. On 28 November XA847 was flown to Boscombe Down for these trials and, in the following January, further tests were made at the Central Fighter Establishment. In addition to trials at official establishments, RAF Fighter Command was to have an intimate connection with P.1B testing from January 1957 onwards. In that month, Sqn Ldr J.L. Dell was posted to Warton as Fighter Command liaison officer. After nearly three years in that capacity, Dell joined English Electric as deputy chief test pilot and made a significant contribution to P.1B flight testing.

The second P.1B, XA853, flew on 5 September, 1957. Used mainly for weapon system development work, the aircraft spent most of its development life at Boscombe Down. XA856, the third prototype, made its initial flight on 3 January, 1958. This aircraft was despatched at the end of March to the Rolls-Royce aerodrome at Hucknall, Derbyshire. There, XA856 was used for nearly ten years in engine development work, being fitted with various marks of Avon engine used in later developments of the P.1B.

XA853, the second P.1B, flying with Firesteak missiles and ventral fuel tank fitted. (*British Aerospace*)

The P.1B was intended to have an auxiliary rocket engine for use at high altitude to improve the rate of climb and ceiling. The designated engine was the Napier Double Scorpion. The application of this engine to the P.1B was not revealed publicly until February 1958, although the Scorpion had by that time been under development for several years. Indeed, in the previous August, the Canberra Double Scorpion flight test-bed had established a new world altitude record. The rocket engine and oxidant were to be installed in the ventral fairing of the P.1B. Fuel for the rocket was, however, to be drawn from the aircraft's tanks. In the event, developments in Avon engine and guided missile performance provided the extra aircraft performance without the need for the rocket. Accordingly, in February 1959, the P.1B installation of the Double Scorpion was cancelled before being fitted to the aircraft.

Intensive flight testing of XA847 continued throughout 1958, the aircraft having made almost 300 flights by the end of the year. The most significant was flight No.282, on 25 November, when Beamont took XA847 to Mach 2 for the first time. This was also the first time any British aircraft had achieved this speed, and a small plaque was later attached to XA847 to record the fact. Mach 2 was sustained in level flight with minimum reheat thrust, and the aircraft carried a ventral fuel tank and was fitted with missile pylons. No aerodynamic problems were encountered and the flight indicated that production aircraft could almost certainly be eventually cleared for speeds above Mach 2.

The only significant problem encountered during the flight testing of the P.1B was a lack of directional stability at high speed. This was corrected on XG310, the fourth development aircraft, by the fitting of a fin with 30 per cent greater area. This larger fin was fitted to all subsequent aircraft before flight and was retro-fitted to earlier aircraft.

XA847 was not used exclusively for test work during 1958. In January, a German mission visited Warton to see flight demonstrations, and in September, a party of United States Air Force officers evaluated the aircraft. That same month XG308, the second development aircraft, and XA847 appeared at the Farnborough air show. By that time the simple designation, P.1, which the type had carried for nearly ten years, had been supplemented by the name, Lightning. English Electric had announced the

A line-up of nine P.1B prototype and development aircraft at Warton, five of which have the larger fin introduced in 1958. (*British Aerospace*)

The Lightning naming ceremony at Farnborough, October 1958, performed by the Chief of the Air Staff, Marshall of the Royal Air Force Sir Dermot Boyle. With him on the rostrum is Sir George Nelson, English Electric Company chairman. (*British Aerospace*)

choice of the name in August, and it was generally considered to be most appropriate, although the aircraft continued to be widely referred to as the P.1. On 23 October, a naming ceremony was held at Farnborough, at which XA847 received the customary bottle of champagne and Beamont produced one of his spectacular flight demonstrations.

The P.1B prototypes had been closely followed through the factory by the batch of development aircraft ordered in February 1954. The first of the 20 aircraft, XG307, made its maiden flight on 3 April, 1958. The twentieth development aircraft, XG337, made its first flight on 5 September, 1959, although the last of the batch to fly was XG333, on 29 September. (Many of the aircraft made their initial flights out of sequence, because of the differing standards of test equipment fitted to individual aircraft). Thus by the autumn of 1959, a total of 23 prototype and development Lightnings were flying. Some of the development aircraft were used in operational trials in 1960 with the Air Fighting Development Squadron (AFDS), based at Coltishall, Norfolk. This unit, which was part of Central Fighter Establishment, received XG334 towards the end of December 1959 and XG335 and XG336 early in 1960. Unfortunately, XG334 was lost in a crash in March following an hydraulic failure the pilot escaped. In May 1960, the two remaining aircraft took part in Exercise *Yeoman*, the annual air defence exercise. Flying from Leconfield in Yorkshire, the two Lightnings were officially stated to have achieved a very satisfactory interception rate.

In addition to the growing number of Service pilots who had flown the Lightning (over 30 by early 1959), more English Electric test pilots became involved in the test flying. Beamont, Hillwood, de Villiers and Dell were joined by J.W.C. Squier, who had previously been involved in Vampire

XG311, the fifth development Lightning, in Aden for tropical trials during October 1961. (*British Aerospace*)

The smoothly blended lines of the two-seat cockpit of the Lightning T.4 are well shown by this photograph of XL628, the first prototype. (*British Aerospace*)

and Canberra testing for the company. Other pilots who were to contribute to development and production flight-testing were T.M.S. Ferguson, J.C. Hall, J.K. Isherwood and D.M. Knight, all of whom had spent several years flying Canberras. Typical test flights lasted about 30 minutes, and during the period of maximum flight-test effort up to six aircraft could be airborne at the same time. Most flights were made over the Irish Sea, and as many were at supersonic speed, there was a complex air traffic control problem. All flights were under radar surveillance from start to finish, Warton's own radar being supplemented by that of the RAF radar stations when necessary. The total number of test flights reached 2,000 in August 1959.

The second Lightning T.4 prototype, XL629, landing at Warton with air-brakes and braking parachute deployed. (*British Aerospace*)

The two-seat trainer version, initially known as the P.11, and later as the T.4, was approaching its first flight by mid-1959. Two prototypes had been ordered in 1956 and this contract was followed by another for 30 aircraft in July 1958. The first of the prototypes, XL628, made its initial flight on 6 May, 1959. Beamont was the pilot for the 30 minute flight, which was made from Warton, a maximum speed of Mach 1.3 being reached. The side-by-side two-seat cockpit was 11½ in wider than that of the single-seat aircraft, the increase in width being minimised by deleting the two Aden cannon in the upper front fuselage. Otherwise the armament was the same as that of the fighter version, and the operational performance was closely comparable. As well as full dual controls, the trainer also had duplicated weapon-system displays, so that an interception mission could be flown from either seat. The Lightning T.4 was the only side-by-side two-seat trainer capable of high supersonic speeds.

Unfortunately, the first prototype, XL628, was lost in an accident during a test flight over the Irish Sea on 1 October, 1959. This was the first Lightning to crash. The aircraft, piloted by Squier, was flying at a height of about 40,000 ft and Mach 1.7. Following a sudden failure, the aircraft went violently out of control, and Squier ejected. At Warton, the loss of radar contact, with no Mayday radio message, led to fears that Squier had been unable to escape from the aircraft. An intensive but fruitless air-sea search appeared to confirm this fear. However, Squier landed safely in the sea and managed to get into his rubber dinghy. He drifted ashore 28 hours later, and despite injuries to his back, ears and eyes, he managed to walk to a farm from where he telephoned to Warton. After a period of rest to recover from his injuries, Squier was able to resume test flying.

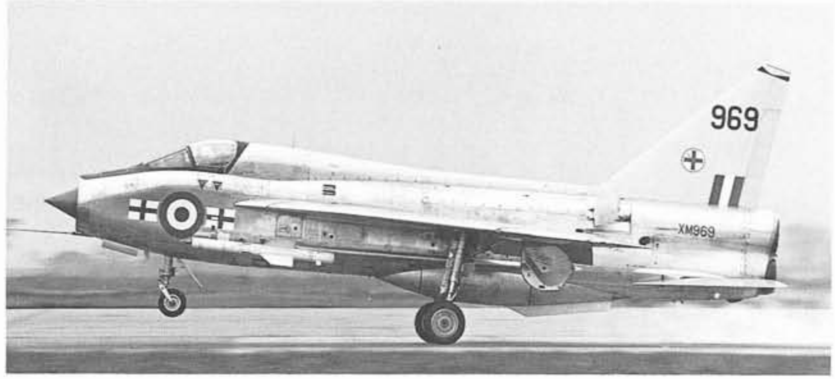
Even before production F.1 aircraft had started to flow from the assembly line, significant progress was being made towards two further developments, the F.2 and F.3. The design work and preparations for manufacture authorised for the F.2 in 1956 were followed in December 1959 by a production contract for fifty aircraft. The F.2 was regarded as an interim production standard between the early F.1 and the far more sophisticated F.3, which was considered to be the definitive standard. In May 1959, the first important steps in the development of the F.3 were

taken. The first issue of the specification for this variant was produced, and approval was given for design work to start and for orders to be placed for long-lead time materials and parts. A requirement also existed for a trainer equivalent to the F.3, and initial design work on this variant was started in November 1959. This version was to be designated the T.5.

The first F.1 production aircraft, XM134, made its initial flight on 29 October, 1959. The second aircraft flew two weeks later, and a further three aircraft followed in December. A steady output of two or three aircraft a month was maintained in the early part of 1960. In March 1960, XM134 was delivered to the A & AEE for work in connection with obtaining Controller of Aircraft (CA) Release for the F.1 before it entered squadron service. Several of the early F.1s were used by English Electric for trials at Warton before being delivered to the RAF. The AFDS was to receive five F.1s for operational trials, these being delivered between May and November 1960. The Lightning F.1 received its CA Release in May 1960, and the following month deliveries to the first operational squadron began. The unit was 74 Squadron, based at Coltishall. XM165 was the first of twelve aircraft to be delivered, arriving at Coltishall on 29 June. The other aircraft were despatched over the next three months, the last being XM146 at the beginning of October. Four of the squadron's aircraft took part in the 1960 Farnborough air show in September, this being the first public appearance of production aircraft. RAF Fighter Command was keen to show its new equipment, and in 1961 a nine-aircraft aerobatic team was formed by 74 Squadron. This team made its début at the Paris air show in June 1961, and three months later made a spectacular appearance at the Farnborough air show. In 1962, the team was the official representative of Fighter Command, using the name, *The Tigers*, derived from the squadron's badge.

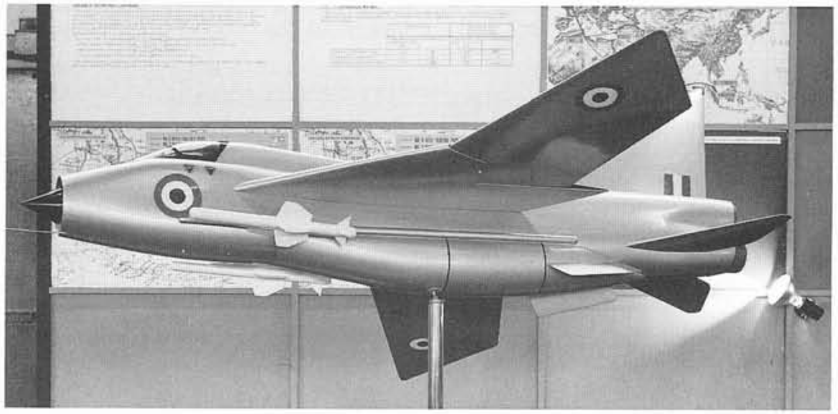
The most important factor that had to be considered when the Lightning was being introduced to RAF Fighter Command was that the aircraft was

XM145, a Lightning F.1 of No.74 Squadron, with engines running in full reheat. A debris guard is fitted over the air intake. Photographed in 1962. (*British Aerospace*)



One of No.226 OCU's Lightning T.4s, XM969, carries the markings of No.145 Squadron, the shadow identity used by the OCU until 1971. XM969, photographed landing at Coltishall in September 1968, served with the OCU for 12 years.

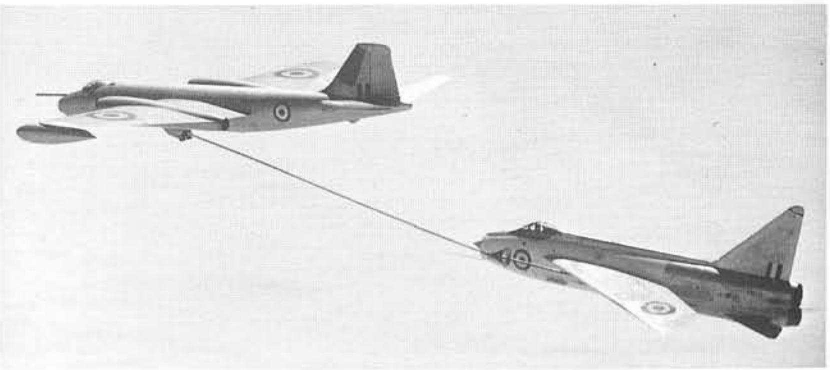
two generations in advance of the types being replaced. The great advance in performance and the introduction of an integrated weapon system made the training of Lightning pilots a more complex task than had previously been the case for new types in Fighter Command. Training was done by the Lightning Conversion Unit, which was eventually to receive Lightning T.4s. However, the unit initially used single-seat squadron aircraft. Before flying a Lightning, a trainee pilot spent many hours in a simulator, this device being used for both flying and weapon-system training. An instructor in a Hunter would accompany the trainee on his early Lightning familiarisation flights. In spite of the relative complexity of the type, it was not found necessary for pilots to have had a great deal of previous experience. When 74 Squadron first received its Lightnings, many of the unit's pilots were on their first tour of duty with a squadron.



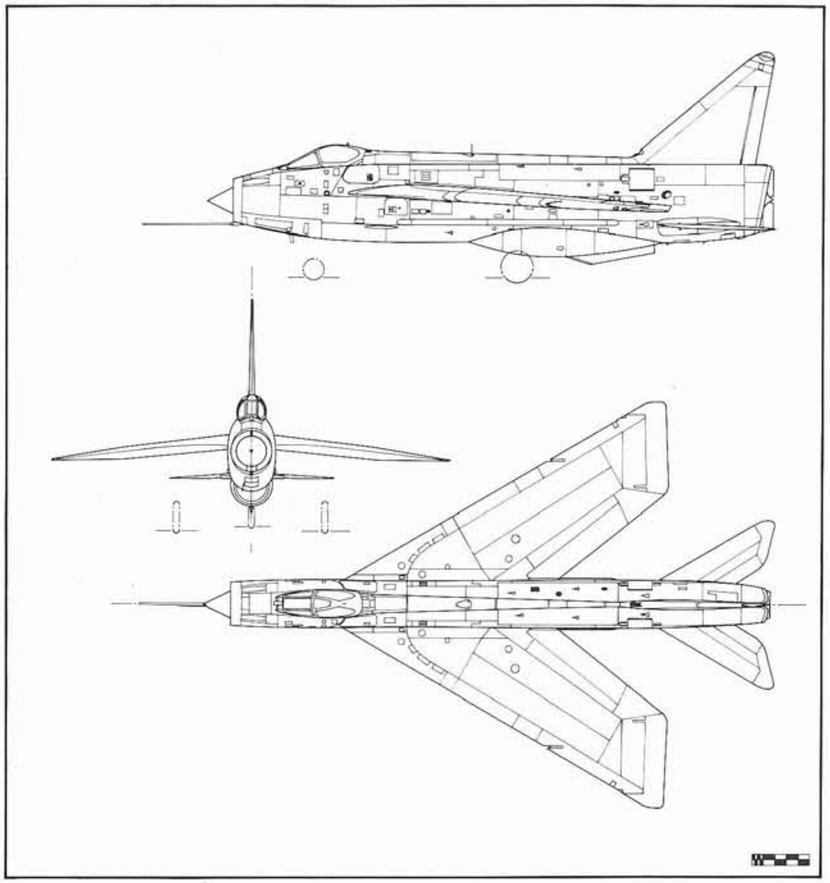
A display model of the variable-geometry Lightning proposal. The model also has the large fuel pack developed for the Mk 6. (*British Aerospace*)

XA847, the first P.1B prototype, fitted with the experimental weapons pack. The effectiveness of the ventral fins on the pack was found to be such that the enlarged dorsal fin was not necessary. Red Top missiles were also carried for flight-tests. (*British Aerospace*)

The development of the Lightning airframe and weapon system up to the standard of the F.1 had been a tremendous task. Nearly three times as many man-hours had been used in designing and developing the P.1B and its weapon system as had been needed to produce the P.1A as a simple research aircraft. Development work did not stop at the F.1, however, as the F.3 was to have a greatly advanced weapon system, which would require an even larger development effort. In addition, other ideas for design improvement were considered. Two of the most significant proposals were for a fighter-bomber version and a research aircraft with variable-geometry wings, of which the latter did not progress beyond preliminary wind-tunnel model tests. The fighter-bomber was to have had a large streamlined under-fuselage pack on and in which weapons could be mounted, and weapon-carrying pylons under the wings. A mock-up of the pack was fitted to the P.1B prototype XA847, the first flight in this configuration being made in June 1960. The lack of a British requirement for this type and of development funds resulted in the project progressing no



The first Lightning F.1A, XM169, during a flight-refuelling test in 1961. The Canberra tanker was WH734, used by Flight Refuelling Ltd as a development aircraft. (*British Aerospace*)

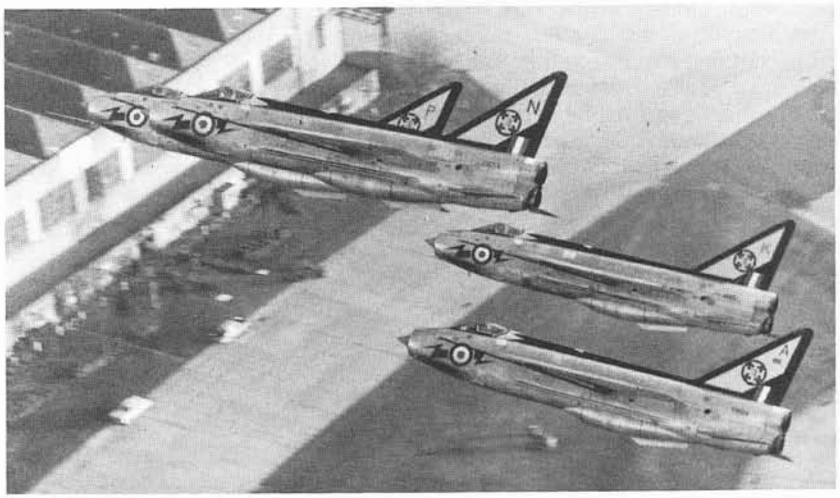


English Electric Lightning F.1A.

further than the trials with XA847. The idea was not forgotten and was incorporated several years later, when circumstances had changed, in the multi-role variant of the Lightning.

After the last F.1 had been completed in July 1960, production continued with a modification of the Mk 1, known as the F.1A. The first example, XM169, flew on 16 August, 1960. The most important new feature of the F.1A was the addition of an in-flight refuelling probe, which had a detachable mounting below the port wing. Other changes were the fitting of UHF radio in place of VHF, and the re-routing of many of the electrical cables in the engine bays in an external duct running along each side of the centre fuselage. The first trials with the flight-refuelling probe had been made in 1959 with XA847, although no fuel was transferred as the object of the trials was to check engagement with the tanker aircraft's drogue. During 1961 XM169 was used for fuel transfer trials at Warton and Boscombe Down, a Canberra acting as tanker aircraft. Delivery of

XM182, an F.1A Lightning of No.56 Squadron, at Wattisham in April 1963. The aircraft is carrying Firestreak missiles, and is in the colour scheme of the *Firebirds* aerobatic team. The fin and spine were painted bright red, as were the wing and tailplane leading edges. (*British Aerospace*)



Four Lightning F.1As of No.111 Squadron flying over their base at Wattisham in 1964. The distinctive fin and spine markings were adopted in mid-1964. (*MAP*)

F.1As to the RAF started on 14 December, 1960, when XM172 was despatched to 56 Squadron, which was based at Wattisham in Suffolk, the squadron reaching its full strength of twelve aircraft in March 1961.

Deliveries to 111 Squadron, also based at Wattisham, followed, their first aircraft, XM185, arriving on 30 March and their last in August.

The last F.1A was followed by the first F.2, XN723, which flew on 11 July, 1961. The F.2 had similar structure, armament and performance to the F.1A, but featured a number of improvements. Among the more significant of these were the fitting of fully-variable reheat; a modified instrument panel conforming to OR 946; the replacement of the gaseous oxygen system by a liquid system; provision of an automatic flight control system; the fitting of improved navigational equipment, and the addition of a stand-by DC electrical generator. The small intake for this generator on the spine was the only external feature which distinguished the F.2 from the F.1A. The F.2 XN723 went to the A & AEE in February 1962 for acceptance trials, and in July, CA Release was granted. The first F.2 for Service trials with the AFDS, XN771, was delivered in November and the first to enter squadron service, XN775, was delivered on 17 December to No.19 Squadron, based at Leconfield. Deliveries were completed in March 1963. The fifth squadron to be re-equipped was No.92, also at Leconfield. Their first aircraft was XN783, which was received on 26 March, 1963. The last F.2, XN797, was completed early in September 1963. This aircraft was placed in reserve storage at 33 Maintenance Unit for several years, as were a number of other F.2s.

Thirteen of the twenty T.4s were completed in 1961, final assembly of some of these being done at Warton instead of at Samlesbury as was normally the case. CA Release for the T.4 was received in August. With the completion of acceptance trials, XM966, the first production T.4, which had made its initial flight on 15 July, 1960, was transferred to Bristol Aircraft at Filton. (Bristol Aircraft was by that time part of the British Aircraft Corporation, as was English Electric Aviation). At Filton, XM966 joined XM967 for conversion to prototype T.5s. The first T.4s delivered for service were XM970 and XM971, which on 27 June, 1962, arrived at

XN731, a Lightning F.2 of No.92 Squadron, is seen in the colourful markings carried by the squadron up to 1968. The fin and spine were royal blue, the arrowhead on the nose being blue and yellow.

Middleton St George, Durham. They were the first aircraft to be received by the Lightning Conversion Squadron (LCS), which had previously used F.1s and F.1As borrowed from operational squadrons. In addition to a further six T.4s despatched to the LCS before the end of the year, two others were delivered to the AFDS in August. One of these was transferred to 74 Squadron after a few weeks, and a single aircraft was delivered to each of the other operational units, 56 and 111 Squadrons. Both 19 and 92 Squadrons, which were being re-equipped with F.2s, received a T.4 before F.2 deliveries began. The T.4s with the LCS were used for conversion and weapon-system training. Those serving with front-line squadrons were used for check-flying and continuation training. The last T.4, XM997, was delivered in January 1963.

The policy of reducing the number of Fighter Command squadrons made it necessary to be able rapidly to redeploy the available squadrons. This practice enabled a relatively small number of Lightning squadrons to perform the commitments previously allotted to a large number of Hunter and Javelin squadrons. In-flight refuelling provision was a feature of all Lightnings after the F.1, in order to enable long-range, nonstop flights to be made to overseas bases. In July 1962, two aircraft of 56 Squadron made the first long-distance overseas flight-refuelled ferry exercise, when they flew nonstop from Wattisham to Akrotiri in Cyprus. They were refuelled three times en route by Valiant tankers. Three months later, four aircraft of the same squadron repeated the exercise. September 1963 saw the technique used for the first time by a complete squadron, when No.111 returned to the United Kingdom from an exercise in Cyprus. Similar exercises to various overseas bases were to be a regular feature of Lightning operational use. As well as undertaking routine training tasks, the Lightning squadrons were frequently called on to provide aircraft to appear at air displays. In 1963, a 56 Squadron team took over from 74 Squadron as the official Fighter Command formation aerobatic team. Known as *The Firebirds*, the team had striking red and white markings on their aircraft. During the summer of 1963, a number of widely acclaimed

A Handley Page Victor of No.57 Squadron refuelling XS923 and XS926, Lightning F.6s of No.5 Squadron.

appearances were made, including those at the Paris and Farnborough air shows.

The Mk 3, which first appeared in 1962, was considered to be a new generation of Lightning. A major advance in weapon-system effectiveness was the most important of its new features, but substantial improvements were also made to the aircraft's engines, structure, most of the systems, and its performance. The Firestreak missiles and weapon system of the earlier Lightnings had been designed for pursuit-course attacks on a target. The advent of the de Havilland Red Top air-to-air missile, developed from the earlier Firestreak, made the use of collision-course interception tactics possible. With the Red Top and radar and weapons-system equipment to match the missile's performance, the Lightning F.3 was to prove an extremely effective interceptor. Although the primary armament was the Red Top missile, provision was retained to carry the earlier Firestreak and the interchangeable rocket pack, but the provision for the Aden cannon pack was removed, as were the mountings for the two Adens in the upper forward fuselage. Thus the F.3 had no cannon, relying entirely on missile armament. The improved AIRPASS equipment included a more advanced AI.23 radar, and features to combat radar countermeasures were included. Interception could be made independently, or with the help of ground control if desired. The early years of Lightning development had seen steady advances in the various fields of systems design, and the F.3 took advantage of these. Better navigation and flight control equipment was fitted, and the cockpit was re-arranged with improved instruments.

In order to improve performance, the F.3 was fitted with the Avon Mk 301 engine, which gave 13,220 lb of thrust without reheat. This was increased to 16,300 lb with full reheat. As a result, rate of climb, manoeuvrability and maximum speed were increased, the in-service clearance speed being above Mach 2. The more powerful engines were coupled with a modified fuel system and increased fuel capacity. Although

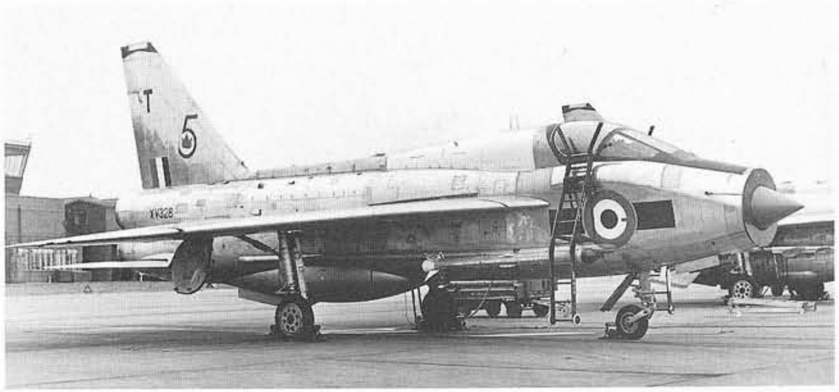
The first of the two Lightning F.2s converted for F.3 development work, XN725 was used for overwing tank trials. Initially the tanks had tail fins, but these were later removed as they caused excessive drag. (*British Aerospace*)

The Lightning F.2 XN725, converted for F.3 development, seen with overwing tanks and a mock-up combat pack. Various missiles and stores could be carried on the pylons on the sides of the pack, but the installation was not fully developed. (*British Aerospace*)

part of the extra fuel was carried internally most was to be contained in two external fuel tanks. Owing to the retraction geometry of the main undercarriage, these tanks could only be mounted on pylons above the wings, being jettisoned if necessary by upward ejection. The capacity of each tank was 260 Imp gal.

Although the basic structure of the F.3 was similar to that of the earlier Lightnings, there were a number of alterations of which only the modification to the fin was readily apparent. The fin was increased in area by 15 per cent and resulted in the fin tip being squared-off.

The development flight-testing of the F.3 was expected to be a large task, and accordingly a number of aircraft were allocated for the work. Most numerous were aircraft from the original P.1B development batch,



One of the last two Lightning T.5s built, XV328 of No.5 Squadron, seen at Binbrook in June 1975. Part of the spine was painted white to reduce the temperature of internal equipment. (*MAP*)

many of which were modified to test various features of the F.3. The first of these was XG310, which in June 1962 made its first flight fitted with the F.3 fin. A further nine aircraft were used in the development of the F.3. These were supplemented by two F.2s, XN725 and XN734, which were modified on the assembly line as F.3 development aircraft. XN725 first flew on 31 March, 1962, with XN734 following four weeks later, both afterwards being used in an intensive test-flying programme at Warton. These aircraft could also carry the over-wing fuel tanks, the first flight with which was made by XN725 in June 1963. The next addition to the Mk 3 development fleet was a true F.3. This aircraft was obtained by giving high priority to the manufacture of the first production aircraft, XP693, which made its maiden flight on 16 June, 1962, from Samlesbury. At that time only half of the F.2 production batch had been completed, and F.3s were not to replace F.2s on the assembly line for another year. However, the importance of the F.3 had been underlined early in 1962 when a second production order was placed. This contract brought the number of F.3s on order to nearly one hundred.

In service, the F.3 was to be complemented by the T.5 trainer, and a production batch of twenty T.5s was ordered in July 1962. As part of the re-allocation of work within BAC, manufacture of two-seat Lightning front fuselages was transferred from Preston to the Filton Division at Bristol. The conversion of two T.4s into prototypes for the T.5 version was also done at Filton, and the first of these aircraft, XM967, was completed early in 1962. The initial flight was made on 29 March, 1962, by Dell. On the following day, XM967 was flown to Warton, where all development flying was to be centred. XM966, the second prototype T.5, was first flown on 1 December, 1962, and again was quickly transferred to Warton. As these T.5s carried the same weapon system as the F.3, they were used in the F.3 development programme as well as in obtaining clearance for the T.5 itself.

The years 1962 to 1964 were probably the busiest in the development history of the Lightning, about 40 test aircraft being used in this period.

Newly delivered Lightning F.3s of No.74 Squadron at Leuchars in August 1964. The fins and spines were black, the nose marking being yellow and black. (*British Aerospace*)

The work was mainly connected with the development of the later marks of Lightning, but a number of aircraft were also engaged in equipment and systems testing and in basic research. Most of the flying was done from Warton but at least six Ministry and industry test centres were also involved. By February 1963, 5,000 Lightning test flights had been made from Warton, and two months later Beamont made his one thousandth Lightning test flight. Approximately three-quarters of all flights were made at supersonic speeds.

By June 1963, the Lightning Conversion Squadron was well established at Middleton St George, the temporary name LCS was discarded and the permanent title 226 Operational Conversion Unit was adopted. During the month the OCU received the first of seven F.1 aircraft, which were to be used for weapons training. The T.4s delivered earlier continued to be used for conversion training. All F.1s had been returned to Warton in 1962 and 1963 for the fitting of UHF radio equipment before being issued to 226 OCU and to 74 Squadron. When 74 Squadron received later marks of Lightnings in 1964, most of its remaining F.1s were handed over to 226 OCU bringing that unit's strength up to fourteen F.1s. No.226 OCU had then also ten T.4s.

The RAF unit charged with the task of overhauling and repairing Lightnings was 33 Maintenance Unit based at Lyneham in Wiltshire. However, with increasing numbers of aircraft entering service, 60 Maintenance Unit at Leconfield also started to undertake some of this work. In 1966, No.60 MU became the main centre for maintenance and repair work done by the RAF and No.33 MU ceased its work on the Lightning. Some of the repair work was not without incident and it was at Lyneham that one of the most remarkable incidents took place. The Lightning F.1 XM135 had been sent to 33 MU for rectification of an electrical alternator fault. On completion of the repair, it was necessary to check the alternator's behaviour at various engine speeds, this requiring a series of high-speed taxi runs. Because a Lightning pilot was not available, they were performed by a technical officer. Three runs were completed without trouble, but at the start of the fourth run reheat was accidently engaged. The officer did not realise this immediately, and was at the same time distracted by a vehicle near the runway. The result was that the Lightning accelerated rapidly, and with insufficient runway left to stop the aircraft, the officer decided to take off. Although a qualified pilot, he had been out of flying practice for nearly ten years. To add to his problem, he had no flying helmet, the aircraft had no canopy or radio, and the ejector-seat was unarmed. With no choice but to attempt a landing, the officer made four unsatisfactory, and no doubt frightening, landing approaches. The fifth approach proved to be much better, and the aircraft touched down safely, although at too great an incidence. The rear fuselage struck the runway, and the damage caused prevented the brake parachute from opening. However, the aircraft was stopped safely on the fortunately long runway. This unique incident thus had a happy ending. XM135 survived to give many years of useful service, and the engineering officer had a superb after-dinner story.

Deliveries to the first operational F.3 squadron started in April 1964. The unit was No.74, which four years previously, had become the first Lightning squadron to be formed. Equipped with F.1s at Coltishall, it

moved to Leuchars, Fife, before receiving F.3s. The first to arrive was XP700, on 14 April. As the number of new aircraft increased, the F.1s were handed over to 226 OCU. The last of the squadron's complement of twelve F.3s was delivered in July, and intensive flying trials with six of the aircraft were made during the following six months. The second F.3 unit to be formed was 23 Squadron, which was based at Leuchars alongside No.74. Re-equipment began on 19 August, 1964, when XP707 and XP708 arrived at Leuchars. The unit was at full strength by November. That month also saw the start of re-equipment of 111 Squadron based at Wattisham with the delivery of XP738 on 4 November, most of the F.1As displaced by F.3s being handed over to 226 OCU. The other squadron with F.1As, No.56, also at Wattisham, became the fourth F.3 unit. Although it had received one F.3, XP765, for training purposes three months earlier, the first of its operational complement, XR719, was not delivered until 16 March, 1965.

If the Lightning had a fault, it was lack of range. This was particularly evident when long-range ferry flights were being undertaken, or when flying patrols were required. In-flight refuelling could overcome the problem, but if the endurance of the aircraft could be improved, fewer refuellings would be needed, operational flexibility would be improved and costs would be reduced. Thus by 1963, the RAF had evolved a requirement for increasing the fuel capacity of the Lightning F.3. No significant quantity of extra fuel could be contained inside the basic airframe, so that increased external tankage became necessary. The large under-fuselage weapons pack, first proposed by English Electric in 1960, had also been considered as a fuel tank. Accordingly, the detail design of a pack to be used only as a fuel tank was started in 1963. The new fuel pack was manufactured in three sections, each being separately attached to the fuselage, and not jettisonable. The fuel capacity of the pack was more than twice that of the original ventral tank. Re-introduction of the cambered wing leading-edges, first tested on the P.1A in 1957, was also proposed. The fitting of these leading-edges reduced subsonic drag and provided the F.3 with a 20 per cent increase in cruising range. With both the large pack and cambered leading-edges fitted, the F.3 was given the provisional designation F.3A.

In 1963, two aircraft were assigned to test the features of the F.3A, the modifications being incorporated at BAC's Filton Division. The first of these aircraft was XP697, the fifth production F.3, which was transferred to Filton for alteration in August, four weeks after its maiden flight. It was followed in September by XN725, one of the F.3 trials aircraft. This aircraft was to be fitted with cambered leading-edges only, for aerodynamic trials with this feature. XN725's first flight in its new role was made at Filton on 26 March, 1964; XP697 became the prototype F.3A, making its initial flight as such on 17 April, also at Filton. Both aircraft were flown back to Warton and for the remainder of 1964 and the whole of 1965 were engaged in handling and development flying.

The Lightning Mk 2 had always been regarded as an interim standard pending the development of the Mk 3. The intention had been to modify the Mk 2 as far as practicable to Mk 3 standard after the latter had been defined, but the advent of the F.3A, with its clear advantages over the F.3, resulted in some of the F.3A's features being included in the proposed changes to the F.2. These aircraft were to be designated F.2A. There was

to be only one prototype F.2A, the F.2 XN795 being selected for the evaluation of the work involved in and the effectiveness of the conversion. The F.2A was to have the weapon-system, radar, Red Top missiles and many of the equipment changes of the F.3 and no cannon armament. It was also to have the F.3-type fin and the large ventral fuel pack of the F.3A but not the later Avon engines and over-wing pylons of the F.3, or the cambered leading-edges of the F.3A. XN795 was returned to Warton in August 1964, and a year later, on 24 September, 1965, made its first flight as the prototype F.2A. For the remainder of the year, and the whole of 1966, it was engaged in test flying at Warton and Boscombe Down.

Production T.5 aircraft joined the F.3s on the assembly line at Samlesbury in 1964. The first flight of the production T.5 took place on 17 July, the aircraft concerned, XS417, being the second aircraft of the batch. (T.5 XS416 had been delayed by its use at the type approval conference). The first T.5s for delivery were completed later in the year, and on 20 April, 1965, XS418 and XS419 were received at Coltishall by 226 OCU. All of the remaining T.5s except two were delivered by the end of 1965, most following the first two to 226 OCU. Single T.5s were allocated to squadrons with F.3s, XS450 being the first of such aircraft, it joining 111 Squadron in September 1965. Production of T.5s was completed in December 1966.

The first contract for F.3s was completed in September 1964, and work on the second order started the following month with XR711. A third batch of F.3s had been ordered in January 1964, taking the total to 125. In late 1964 the Ministry ordered eight T.5s and twelve F.3s; but these orders were later reduced or cancelled, and only two of the T.5s (XV328 and XV329) were eventually built for the RAF. These were the last Lightnings to be ordered on behalf of the RAF.

The year 1965 was one of change and expansion at 226 OCU. To allow for the coming expansion, the unit had moved from Middleton St George to Coltishall in 1964. Deliveries of the expected additional aircraft began in the spring of 1965. During the year thirteen T.5s were received, and were used to train pilots to operate the weapon-system and missiles of the F.3. The fourteen F.1s, which had been used by the OCU for flying and weapons training, were progressively withdrawn and replaced by sixteen F.1As. The unit continued to use its ten T.4s for initial flying training and for weapon-system training of pilots destined for F.2 squadrons. By the end of 1965, therefore, the OCU had a total of 39 aircraft, and Coltishall was without doubt the busiest of the Lightning bases.

An important milestone in the Lightning's Service history was reached in the autumn of 1965, when, for the first time, a squadron was permanently based overseas. On 23 September, the F.2s of 19 Squadron moved from Leconfield to Gütersloh in Germany. At Gütersloh, 19 Squadron operated as part of the Second Tactical Air Force under NATO control. A second Lightning F.2 unit, 92 Squadron, was also transferred to Germany at the end of the year. The move from Leconfield to Geilenkirchen took place on 29 December.

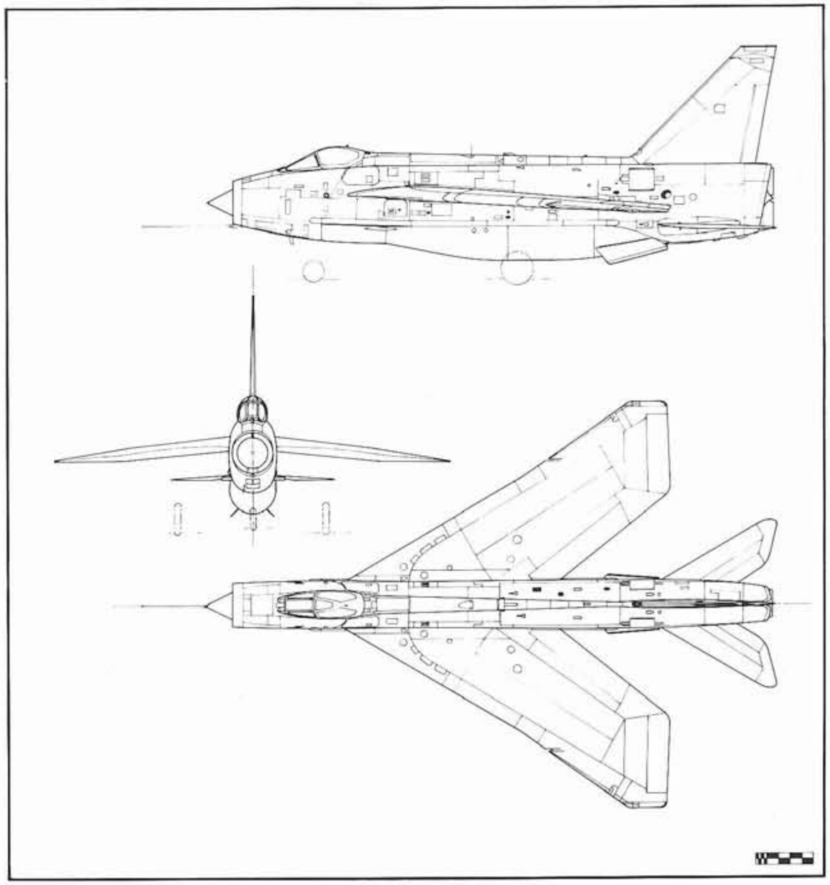
The advent of the Lightning Mk 3A offered the possibility of developing more versatile versions of the aircraft. The lack of such versions had been the primary cause of failure to export the Lightning. Any multi-role fighter had an enormous advantage in a sales competition with the highly

specialised interceptor. If a multi-role Lightning could be produced, however, export sales of the type were still possible, although by 1964 many of the largest potential markets had been taken by other aircraft. Therefore, in 1964, the Warton design team again started seriously to consider the development of a multi-role Lightning. Such an aircraft would have to carry guns, bombs and rockets, and also reconnaissance equipment if possible. At the same time, the ability to operate as an interceptor must not be impaired.

The re-introduction of guns into the Lightning would have been a problem if the ventral fuel pack had not been developed for the F.3A. The forward section of this pack was an ideal position for the installation of two 30 mm Aden cannon. There was sufficient space for the two cannon and all their ammunition, and the volume left over could still be used for fuel. Hence the loss of fuel from the pack, about 15 per cent, was not too significant. The carriage of stores such as bombs and rockets required the fitting of wing pylons. Over-wing pylons had already been designed for the F.3's external fuel tanks, and with upward ejectors these pylons could be used for bombs and rocket pods. However, in order to increase the stores load, an under-wing pylon was added near to each wingtip. The stowage of reconnaissance equipment proved to be relatively easy, as the detachable missile pack which formed part of the lower front fuselage could readily be adapted. The existing pack could carry Red Top or Firestreak missiles, or 2-in rockets. For reconnaissance work alternative pack designs could carry cameras or electronic equipment, for day or night use.

In 1964 there were a number of countries with a requirement for a fighter aircraft that could be met by the proposed multi-role Lightning. One of the more tempting prospects was Saudi Arabia, which had a requirement for a complete air defence system, that would include a substantial number of high-performance fighters. During July 1964 an RAF Lightning F.3, which was engaged in trials in the Middle East, was loaned to BAC for demonstration in Saudi Arabia. In August a Saudi party arrived at Warton to make a detailed evaluation of the Lightning, and also to see the production and development facilities of the Preston Division. An F.2 aircraft, XN795, flown by Dell, gave an impressive demonstration over Warton, and members of the Saudi party were flown in the T.4s, XM968 and XM995. After dual instruction, a Saudi pilot flew a Lightning solo. The results of this visit were not, however, to become apparent for over a year.

Towards the end of 1964 BAC's multi-role Lightning development work was centred on the Saudi Arabian requirement. Multi-role derivatives of both the F.2A and F.3A were considered, with the provisional designations F.2B and F.3B respectively, although the main emphasis was on developments of the F.3A. A trainer equivalent of the F.3A was also investigated, this being the T.5A version of the T.5. During the year, the Saudi Arabian air defence system requirement had crystallised into four parts. The most important was for a force of about 40 fighter aircraft, the Lightning and Lockheed F-104G being in competition for this order. The second part of the requirement was for ground-to-air anti-aircraft missiles to supplement the fighters. The third element was a system of ground radar stations to detect hostile aircraft, and to control the fighter force. Training aircraft and services comprised the fourth part of the requirement.



BAC Lightning F.6.

While BAC's design departments were working on the multi-role Lightning, the production organization was concerned with introducing the F.3A onto the assembly line. During 1965, the F.3A, also referred to as the Mk 3 ERV (Extended Range Version) by the RAF, was redesignated the F.6. The second and third contracts for F.3 aircraft were amended to call for F.6s, most of the second order and the whole of the third being affected. Thus all single-seat aircraft produced after late 1964 had to be delivered as F.6s. As the manufacturing cycle was well over a year, numerous aircraft at various stages of assembly as F.3s had to be converted to F.6s before delivery.

The first Mk 6s to be delivered to the RAF were to be from a batch of aircraft built on the assembly line to an interim standard, and were known as the F.6 (Interim). They had only the cambered leading-edges and fuel pack of the F.6. The F.6 (Interim) aircraft were intended for Service trials, and were also to equip one squadron. However, they were to be replaced

Lightning F.3 XP697 after conversion to become the F.6 prototype. Notable features are the extended cambered wing leading edge, ventral fuel pack, overwing tanks without tail fins, Red Top missiles and flight-refuelling probe. (*British Aerospace*)

when sufficient full standard F.6s became available, the interim mark then being returned to Warton for complete F.6 conversion. XR752, the first F.6 (Interim), flew at Samlesbury on 16 June, 1965, piloted by de Villiers. The remainder of the batch of 16 aircraft were completed by the end of the year. In November, XR752 and XR753 were delivered to the AFDS at Binbrook for Service trials, with XR754 going to the Handling Squadron at Boscombe Down the following month.

CA Release for the F.6 (Interim) was granted in October 1965, and deliveries for squadron service started in December. XR755 and XR756 left Warton on the tenth of the month, going to No.5 Squadron, based at Binbrook alongside the AFDS. In service, the Mk 6 was regarded as the long-range Lightning, with the Mk 3 being used mainly for shorter range missions. Hence, although all the Mk 3 and Mk 5 aircraft had been built with provision to carry over-wing fuel tanks, they were not used in service. The over-wing tanks, however, were standard equipment on the F.6 when it was operated in the ferry role, trials for which were made with the F.6 prototype XP697 late in 1965.

The year 1965 saw Lightning production at its peak, nearly 50 aircraft of four marks being produced. In January, the two hundredth aircraft was completed, this being an F.3. During the early months of the year Lightning work was undertaken in parallel with the TSR.2 programme. Following the cancellation of TSR.2 in April, the Lightning was again the main source of work for the Preston factory, with new orders urgently needed if production was to continue after 1967. Fortunately, the multi-role export versions of the Lightning were being seriously considered by a number of countries, and prospects for large overseas contracts appeared bright. Particularly strong interest in the multi-role Lightning was shown by Middle Eastern and by South American countries.

The Lightning's export breakthrough came in December 1965. On the twenty-first of the month an announcement was made that Saudi Arabia

was to place a massive contract with a group of British and American companies for an air defence system. For the purpose of fulfilling the contract, the companies concerned formed the Saudi Arabian Air Defence Consortium. The total value of the contract was about £125 million, of which approximately £65 million was for aircraft to be supplied by BAC. These were to be forty Lightning fighters and twenty-five BAC 167 Strikemaster trainers. Hawk anti-aircraft missiles were to be supplied by the American Raytheon company, and the British firm of Associated Electrical Industries was to supply air defence and surveillance radars. The large training and support effort required to operate the air defence system was to be provided by Airwork Services. The British part of the contract, which was worth over £100 million, was the largest export order ever received by Britain. Although work started immediately in December 1965, the full formal contract was not signed until May 1966.

Of the forty Saudi Arabian Lightnings, thirty-four were to be single-seat multi-role fighters, derived from the F.3 and F.6, and designated the F.53. The remaining six aircraft were to be two-seat trainers, based on the T.5, but known as the T.55. All were to be new production aircraft. Although the F.53 was mainly based on the F.3, it was also to have the new features introduced in the F.6, as well as the changes necessary to perform ground attack and reconnaissance roles. BAC's first priority on receiving the Saudi order was to develop the multi-role Lightning as quickly as possible, as only design study and wind-tunnel work had been done previously. Flying prototypes of both the F.53 and T.55 versions were urgently needed, and accordingly BAC bought two Lightnings (F.3 XR722 and T.5 XS460) from the RAF for conversion. Work on these aircraft started early in 1966.

One of the Saudi requirements was that the Lightning aircraft for training should be supplied as soon as possible. BAC received separate contracts for these in March and April 1966. The first was for two T.4

The RAF Lightning T.4 XM989 became a Royal Saudi Air Force T.54 as 54-650. It was the first Lightning to be painted in Saudi markings. The photograph shows the fuselage roundel in its initial position, it was moved to the front fuselage before the aircraft was delivered in June 1966 (*British Aerospace*)

The four Lightning F.52s delivered to Saudi Arabia in July 1966 lined up at Warton before despatch. (*British Aerospace*)

trainers, which were to be ex-RAF aircraft, supplied to Saudi Arabia as T.54s. The second contract called for four F.2 fighters. Again these were to be ex-RAF, and in Saudi service they were known as F.52s. All six aircraft were prepared for delivery at Warton, the work consisting only of repainting, routine maintenance and the fitting of a temporary ferry radio. Although the two T.4s had been in RAF squadron service, all of the four F.2s came from reserve storage, and had never been in service. The T.4s arrived at Warton early in April 1966, with the F.2s following a few weeks later. By the end of July, all six aircraft had been delivered to Saudi Arabia, where they entered service with No.6 Squadron Royal Saudi Air Force, based at Khamis Mushyat.

Work on the new Saudi aircraft was well under way in the early months of 1966 and given the highest priority. Progress was rapid, so that by the end of the year the major assemblies for the first F.53 and T.55 aircraft were nearly ready for transport to Samlesbury for marry-up. At the Farnborough air show in September, BAC showed a representative multi-role Lightning in the guise of the F.6 prototype XP697, which was fitted with mock-up under-wing pylons, and was statically displayed carrying rocket launcher pods. A range of other stores was laid out round the air-

Lightnings based at Leuchars, on the east coast of Scotland, frequently intercepted Soviet reconnaissance aircraft in the 1970s. An F.6 of No.23 Squadron is seen escorting a Tupolev Tu-20 (Bear D). (*British Aerospace*)

craft. Another F.6, XR770, was painted in Saudi Arabian markings and took part in the flying display.

By the end of 1966, only fifteen F.6s remained to be completed at Samlesbury. XS920 was the first full standard F.6 to be completed, making its maiden flight in October. The first F.6, XR768, to be delivered arrived at Leuchars on 1 August, 1966, for 74 Squadron. This unit, which had Lightning F.3s, was completely re-equipped by December. Deliveries to 5 Squadron at Binbrook started on the thirtieth of the same month, XS922 being the first despatched. No.74 Squadron was quick to use the increased range of its F.6s, and in November 1966, the RAF revealed that the squadron's aircraft were frequently intercepting Soviet reconnaissance flights.

Several Lightning units of a new type were formed in 1966. These were Target Facilities Flights (TFFs), one of which was formed at each of the operational Lightning bases. By the end of the year, TFFs were active at Leuchars, Binbrook and Wattisham, each base being equipped with two or three Lightning F.1s. These out-of-date aircraft were used to simulate the enemy, thus providing realistic targets against which the operational squadrons could perform practice interceptions.

Evaluation of the prototype F.2A, XN795, had been completed by early 1966, and in July, BAC received approval for work to start modifying a further 30 aircraft. These were, however, to be to a very different standard to that of XN795. Instead of producing the aircraft to the basic F.3 standard, they were built incorporating features of the F.6. The overall result was that the aircraft's performance was significantly improved at relatively low cost. The necessary design work for the production F.2A conversions was done at Warton in the summer of 1966, with the first aircraft for conversion, XN789, arriving on 5 September. Further F.2s, from storage as well as from 19 and 92 Squadrons, arrived at Warton in rotation over the next three years.

The first Kuwaiti Lightning F.53K, 53-412/G27-80. (*British Aerospace*)

The Lightning export sales effort, which had been intensified after the Saudi Arabian contract, achieved its second success in December 1966. On the eighteenth, a contract was signed with Kuwait for the supply of fourteen aircraft. This order was worth over £20 million, and brought the total value of Lightning exports to about £85 million. The fourteen aircraft were to comprise twelve single-seat F.53Ks and two T.55K trainers. Both of these versions were very similar to the Saudi Arabian F.53 and T.55 variants, the small differences being indicated by the 'K' suffixes to the designations.

The prototype Lightning F.53, G27-2/53-666, with Royal Saudi Air Force markings. The aircraft is carrying a rocket pod on each underwing pylon, and an Aden gun pack is fitted in place of the forward part of the ventral fuel pack. A mock-up reconnaissance pack is carried in front of the gun pack. (*British Aerospace*)

Both of the Saudi Arabian prototype aircraft were completed by November 1966. The prototype F.53 first flew on 1 November, carrying the Saudi serial number 53–666. Two days later, the T.55 prototype made its maiden flight, with the serial number 55–710. The flights were made at Warton, and both aircraft were immediately involved in intensive test flying. The single-seater, 53–666, was mainly used for development flying with external weapons. Under-wing pylons were fitted for the first time five weeks after the maiden flight, and eight days later, 1,000 lb bombs were carried on the pylons. In February 1967, MATRA rocket launcher pods were carried, and in April, air firing tests were made with the pods, each of which contained eighteen 68 mm air-to-ground rockets. Ground firing trials of the gun pack, which could replace the forward section of the ventral fuel pack, began in May. The F.53, 53–666, first carried the gun pack in late September, and in early December a successful first air-firing trial was made.

The testing of the T.55 prototype, 55–710, did not, however, proceed so smoothly. On 7 March, 1967, the aircraft veered off the runway on landing at Warton, one of the main undercarriage legs collapsed, and the aircraft was very severely damaged before it came to rest. Fortunately, the injuries suffered by the two crew members were not serious. An extra T.55 was built to replace 55–710.

The last RAF aircraft to come from the assembly line was XS938, an F.6, which first flew on 30 June, 1967. This aircraft was despatched on 28

Lightning F.6 XS933 of No.11 Squadron at Binbrook in 1968. (*MAP*)

August, but it was not the last Lightning to be delivered, as several interim F.6s, held at Warton for modification to full standard, were despatched after XS938. Following the completion of F.6 deliveries to 74 and 5 Squadrons, the next units to receive the type were Nos.11 and 23. No.11 Squadron was the eighth to be equipped with Lightnings, the first aircraft, XS928, being delivered to the squadron's base at Leuchars on 4 April, 1967. No.23 Squadron was also based at Leuchars, and the replacement of the unit's F.3s with F.6s started on 15 August, 1967, with the arrival of XR725. The squadron was, however, to use six F.6 (Interim) aircraft for training purposes for several months before the F.6s arrived.

Some of the F.3s displaced by F.6s were used to equip the ninth Lightning unit, 29 Squadron. Previously flying Gloster Javelins and based at Akrotiri, the squadron returned home in April 1967. It was based at Wattisham, and started to receive Lightnings in May. No.56 Squadron, which was also at Wattisham with F.3s, was then moved to Cyprus as the replacement for No.29. No.56 Squadron, therefore, became the first Lightning unit in the Middle East area, providing protection for the British bases in Cyprus.

June 1967 saw Lightnings enter service in the Far East. No.74 Squadron, based at Leuchars alongside Nos.11 and 23, was the unit concerned. The first six of 74 Squadron's F.6s left Leuchars for Singapore on 4 June, with five more leaving the next day and the last two on the sixth. The aircraft were staged through Cyprus, Bahrain and Gan, several refuellings being made during each leg of the flight. Seventeen Victor tankers were needed for this task, two of the four legs requiring over five hours' flying time. The last aircraft arrived at Tengah on 11 June, and the squadron was operational the following day. These were the first Lightnings ever to have operated with the RAF's Far East Air Force, and they replaced a Javelin squadron which had been disbanded. No.74 Squadron's T.5 aircraft were shipped to Tengah.

By the end of 1967, the RAF's operational Lightning force had reached maximum strength. The equipment and bases of the nine squadrons were

Three of the four Royal Saudi Air Force Lightning T.55s that were used for pilot training by No.226 OCU at Coltishall in 1968. Seen here are 55-713 (C), 55-714 (D) and 55-711 (A). (*British Aerospace*)

to remain substantially unchanged for several years. Five of the squadrons were stationed in the United Kingdom, Nos.11 and 23 at Leuchars having F.6s, No.5 Squadron at Binbrook also with F.6s, and Nos.29 and 111 at Wattisham with F.3s. In Germany, 19 Squadron at Gütersloh and No.92 at Geilenkirchen both had F.2s. In Cyprus, 56 Squadron at Akrotiri had F.3s, and in the Far East, No.74 at Tengah had F.6s. Thus the RAF's front-line Lightning force covered Britain and the main areas of British interest around the world, even if the cover was rather thin in some areas.

Deliveries of new Lightnings to the RAF were completed in January 1968 with the despatch of F.3 XR751 from Warton. The volume of Lightning work at Warton, however, did not diminish, as the F.2A conversion programme was under way. The first of the batch of 30 aircraft to be completed was XN789, which made its first flight as an F.2A on 12

The first new Lightnings delivered to Saudi Arabia were two F.53s, 53-681 and 53-682. The former is seen taxi-ing out for the delivery flight from Warton on 1 July, 1968. (*British Aerospace*)

October, 1967. Early in January 1968, it went to the A & AEE at Boscombe Down for acceptance trials. The second conversion to be completed, XN781, was the first to be delivered, the aircraft going to 19 Squadron in February 1968. The first aircraft for 92 Squadron was XN773, which was delivered in June. Both squadrons were fully equipped with F.2As by September 1969, and by that time they were both based at Gütersloh.

After the first Saudi F.53 and T.55 aircraft had made their maiden flights in the summer of 1967, a further eight fighters and two trainers flew before the end of the year. The first aircraft to be handed over to Saudi Arabian charge were 53-667 and 55-711, the event being marked by a brief ceremony at Warton in December. However, both aircraft remained at Warton for some time, as many of the Saudi aircraft were stored there for several months before despatch. The first aircraft to leave were four T.55s, which went to RAF Coltishall early in 1968. They were used for about 18 months by 226 OCU for the training of Saudi pilots. F.53 fighter production for Saudi Arabia continued steadily during 1968 and ended in December. Only one T.55 trainer remained to be completed, and aircraft for Kuwait occupied the assembly line.

Deliveries to Saudi Arabia started on 1 July, 1968, when two F.53s, 53-681 and 53-682, flew from Warton to Jeddah. Further delivery flights took place once or twice a month over the next year. The nonstop flights were made possible by several in-flight refuellings from RAF Victor tankers in the course of the 3,000 mile journey. The BAC and Airwork pilots involved were thus making flights lasting between six and seven hours, which, due to the pleasant flying qualities of the Lightning, were not the endurance test they would have been in many other types of single-seat fighter. It was during the delivery of Saudi Arabian Lightnings that BAC

A unique group of Lightnings flying from Warton in July 1968. Leading is the first Kuwaiti T.55, 55-410/G27-78, carrying Firestreak missiles. Nearest the camera is the unpainted Saudi F.53 53-686/G27-56, fitted with a gun pack, and with bombs on the underwing pylons. The third aircraft is an RAF F.6, XR759, carrying Red Top missiles. (*British Aerospace*)

had the occasion to use the British civil Class B type of registration. This was in May 1967, when T.52 Saudi serial 659 (ex XN729) was registered G27-1. All subsequent export Lightnings carried these registrations for test flying before delivery.

Development and production test flying of both RAF and export Lightnings was done during 1967 and 1968, with delivery flights to Saudi Arabia and Kuwait being extra tasks. By the middle of 1968, a total of 10,000 Lightning test flights had been made from Warton, three quarters of these being at supersonic speeds. Five company test pilots had then each made over 1,000 test flights: Beamont, Dell, de Villiers, Knight and Ferguson. Beamont made his last Lightning test flight on 28 March, 1968, when he took the Saudi aircraft 53-681 up on its maiden flight. In the course of thirteen years he had made 1,300 flights in twelve versions of the type.

The first Kuwaiti Lightning to fly was 410, one of two T.55K trainers ordered. This aircraft made its maiden flight on 24 May, 1968, and the first F.53K for Kuwait, 412, followed on 21 June, 1968. However, most of the Kuwaiti aircraft did not fly until 1969, as they were following the Saudi aircraft on the assembly line. Deliveries to Kuwait began on 18 December, 1968, when 410 and 412 were despatched. The delivery flights followed a similar route and procedure as those to Saudi Arabia, and on several occasions aircraft for Saudi Arabia and Kuwait flew most of the way together.

F.53 development flying at Warton continued throughout 1968, using the prototype aircraft, 53-666. While development flying progressed smoothly, production test flying suffered a setback on 4 September, when the Saudi F.53 53-690 was lost in a crash near Warton. The aircraft caught fire soon after take-off and with control becoming progressively more difficult, the pilot, J. Cockburn, headed out to sea and ejected. The aircraft, however, became unstable and crashed near the coast in the

Royal Saudi Air Force Lightning F.53 53-686 was displayed at the 1968 SBAC Exhibition as G-AWON. An Aden gun pack and a 2-in rocket pack were carried beneath the fuselage. The underwing pylons each had two rocket pods, and the overwing pylons each carried two mock-ups of the combined rocket pod and fuel tank. Laid out round the aircraft were a camera pack, guided missiles, guns, rockets, bombs and fuel tanks. (*British Aerospace*)

village of Pilling, fortunately without causing injury or serious damage. An extra F.53 was built to replace 53-690, which was the only Lightning lost in the course of production test flying over a period of ten years.

At the 1968 Farnborough air show, BAC were, for the first time, able to show a true multi-role Lightning. The Saudi aircraft 53-687 appeared in the flying display carrying gun and camera packs, and 53-686 was shown in the static park. For their show appearance, these two aircraft had the British civil registrations G-AWOO and G-AWON respectively. This was the first time that such registrations had been allocated to Lightnings. Among the impressive array of stores displayed with 53-686, were two new features designed to increase the Lightning's weapon load. An adapter fitted to the under-wing pylons enabled two bombs or rocket pods to be carried on each pylon, so that, with the ordinary over-wing pylons, the aircraft could carry six bombs or rocket pods. The adaptor was later flight cleared and supplied to Saudi Arabia. The second new feature was an adaptor to increase the load carried on the over-wing pylon. This adaptor could carry two long slim fuel tanks, each of which had a rocket-launching pod built into the nose. Thus both the weapon and external fuel loads could be increased. However, this installation was never fully developed, only mock-ups were built. With both the under-wing and over-wing pylon adaptors fitted, the Lightning could have carried eight rocket pods, with a total of one hundred and forty-four 68 mm rockets.

Only twelve Lightnings were built in 1969, all except one being for Kuwait. Deliveries to Saudi Arabia were completed in September 1969, and those to Kuwait were finished in December. Thus at the end of 1969 further export orders were urgently needed if the Lightning was to remain in production. An intensive Lightning sales campaign was undertaken from 1967 in many parts of the world, but particularly in the Middle East and South America. Many countries showed serious interest, and negotiations reached an advanced stage with several potential customers.

The last three Lightnings for Kuwait about to leave Warton on delivery, in the early morning darkness of 3 December, 1969. The aircraft were T.55 55-411 and F.53s 53-422 and 53-423. (*British Aerospace*)

No orders were received, however, for a variety of reasons. French and American aircraft proved to be tough competitors and political and economic factors also weighed heavily against the Lightning and proved decisive in several sales competitions. By 1970, however, sales prospects were seen to be diminishing and around the end of the year, Lightning production facilities started to be re-allocated to other work. Only the one replacement Saudi F.53 remained to be completed, most of the work on this aircraft being done at Samlesbury, as the assembly jigs had been removed from the Strand Road factory. The total number of Lightnings built was 340, of which 54 were for export.

Saudi Arabian Lightnings first became operational with the Royal Saudi Air Force in the summer of 1969, although training work was the main activity at that time. An Operational Conversion Unit was formed at Dhahran to undertake pilot training, and a ground crew training centre and maintenance base was established at Riyadh. The main operational bases were at Dhahran, Riyadh and Khamis Mushyat. In December 1969 trouble in a remote area on the border with South Yemen was settled by the RSAF almost without any help from ground forces. Lightnings were involved in this action, flying ground attack sorties. This was the first time ever that the type had been used in anger.

The RAF squadrons equipped with F.6 aircraft were frequently engaged in long-distance training flights. These were intended to maintain their ability to reinforce rapidly the Lightnings in Cyprus or Singapore, or to move to any other area which might be necessary. Sometimes these training flights were combined with other objects. An example of such a flight was the visit of two 23 Squadron aircraft to Canada in August 1968, where they took part in the Toronto international air show. These aircraft, XR725 and XS936, were the first Lightnings to cross the Atlantic.

The efficiency of the Lightning in the air defence role was demonstrated in June 1970, when 5 Squadron won the Huddleston Trophy. Four types of fighter flown by eight air forces competed for the trophy, awarded to the NATO fighter squadron with the best performance as an air defence unit. Late in 1968, trials started at Warton which were to increase the versatility of RAF Lightnings. The gun pack which could replace the forward part of the ventral pack had been adopted by the RAF, and acceptance trials were

When Supermarine Spitfire PR.19 PS853 visited Warton in October 1970, it was photographed with Lightning F.2A XN773 of No.92 Squadron. Outwardly the F.2A resembles the F.6, the only apparent difference being the gun break-outs in the nose of the F.2A (*British Aerospace*)

made with the F.6 trials aircraft XP693. All of the F.6 and F.2A squadrons eventually received gun packs.

Lightning work at Warton almost ceased after September 1970, when the F.2A conversion programme was completed. The last of the 30 aircraft were returned to Warton during the following year for minor modifications. By that time the Strand Road factory was occupied by work for the Jaguar ground-attack fighter.

The tenth anniversary of the Lightning's entry into squadron service occurred in June 1970. The unit concerned, 74 Squadron, was still flying Lightnings, having had F.1 and F.3 aircraft before its current F.6s. Several of the original F.1s were still active in 1970, being flown by Target Facilities Flights. In spite of having served for ten years, the Lightning remained the RAF's primary front-line air defence fighter, with no replacement being envisaged for several years. March 1971 saw 111 Squadron complete ten years of Lightning operations. This unit, which had operated F.1As and F.3s, was notable for having remained at Wattisham for the whole of the ten-year period. It was also noted for the performances given by its aerobatic team, which had been formed in 1965.

Lightnings ranged further than ever in April 1971, when three of 74 Squadron's aircraft visited Southern Australia from their base at Tengah. The aircraft, XR764, XS897 and XS921, took part in a display at Laverton, near Melbourne, to mark the fiftieth anniversary of the Royal Australian Air Force. No.74 Squadron was not to remain in Singapore for long, however, for on 25 August, 1971, the unit was disbanded. This move was due to the withdrawal of British forces from Singapore, and the squadron's base at Tengah was handed over to the Singapore Government. The squadron was the first Lightning unit to be disbanded, having operated the type for eleven years. All of the squadron's F.6s were ferried to Cyprus, where most were handed over to 56 Squadron. With the addition of four more F.6s newly arrived from overhaul in the United Kingdom, No.56 was fully equipped with F.6s by early 1972. The F.3s displaced from the squadron were returned to Britain for storage or re-issue to other units.

A small number of F.3s was allocated to 226 OCU from May 1970, for

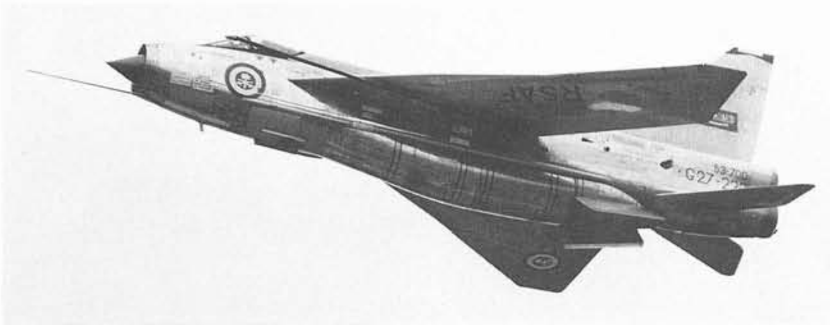
All Lightnings were unpainted until 1972, when those in RAF Germany started to have their sides and upper surfaces finished in dark green. T.4 XM973 of No.19 Squadron is seen here in that paint scheme in 1976.

weapons-systems training. Three more, of which two were ex-56 Squadron aircraft, were delivered late in 1971, bringing the total to seven. Thus by 1972, the OCU was using four different marks of Lightning, the fleet of F.1A, F.3, T.4 and T.5 aircraft being over 30 strong. These were divided into two squadrons. The F.1As and T.4s formed 65 Squadron, with the F.3s and T.5s being operated as 2(T) Squadron. June 1972 was the tenth anniversary of Lightning operations by the OCU, and its predecessor, the Lightning Conversion Squadron. Four of the T.4s delivered to the unit in 1962 were still in service, these aircraft being XM969, XM970, XM972 and XM987.

The last Lightning built, the single Saudi replacement F.53, was completed in the summer of 1972. With the serial number 53-700, and the temporary registration G27-223, this aircraft made its first flight on 29 June from Samlesbury, piloted by P. Ginger. Despatch to Saudi Arabia was on 4 September.

The RAF's long-term plan was that the Phantom would become the primary air-defence fighter aircraft. However, it was intended that a reduced force of Lightnings would continue in service alongside the Phantom into the 1980s. Accordingly, measures were introduced in 1973 to prolong the life of F.6 Lightnings. The more versatile F.6s, also the youngest aircraft in the fleet, were to equip Lightning squadrons in the 1980s. The life extension measures included structural modifications and changes in aircraft use. During 1973 each of the United Kingdom-based F.6 squadrons received a few F.3s, these aircraft being used mainly for non-operational work, such as training and check flying, thus saving F.6 flying hours.

The withdrawal of Lightnings from service began in 1974. The first to go were from the Target Facilities Flights at Leuchars, Binbrook and Wattisham, which had been operating a few F.1 or F.1A aircraft. All TFF aircraft had ceased flying by mid-1974, most having been in service with various units since 1960 or 1961. These were the last Lightnings to be



The last Lightning built was 53-700/G27-223, the replacement F.53 for Saudi Arabia. It is seen here during its first flight, on 29 June, 1972. (*British Aerospace*)

specially assigned to target work, the F.2s used for this purpose in Germany having been grounded in 1973.

An inevitable consequence of the prospect of progressively fewer Lightnings in service was a greatly reduced demand for pilot training. Accordingly, 226 OCU was disbanded in the summer of 1974. Only the unit's T.5 aircraft were retained for training, being transferred to the newly formed Lightning Conversion Flight at Binbrook. Most of the OCU's F.1A, T.4 and F.3 aircraft were either placed in store or scrapped.

Deliveries of Jaguars to operational squadrons started in 1974, releasing Phantoms for the air defence role. The two Lightning squadrons equipped with F.3s, Nos.29 and 111 at Wattisham, were the first to be replaced by Phantoms. No.111 Squadron disbanded at the end of September, after having operated Lightnings for over 13 years. No.29 Squadron, which had flown F.3s for over seven years, disbanded at the end of 1974. New Phantom squadrons, using the same numbers, were formed at Coningsby.

When Lightning F.3s were withdrawn from squadron service, some were scrapped in 1975 at 60 MU Leconfield. This example, XP708, ex-No.29 Squadron, has been stripped of useful spares before scrapping. (*MAP*)

Lightning T.5 XV328 of the Lightning Training Flight at Binbrook in 1980. The green and grey camouflage scheme was standard by that time. (*MAP*)

Lightning F.3 XP753 of the Lightning Training Flight was the official flying display Lightning in 1983. It is seen here in an experimental two-tone grey paint scheme, at the Mildenhall display in May 1983. (*MAP*)

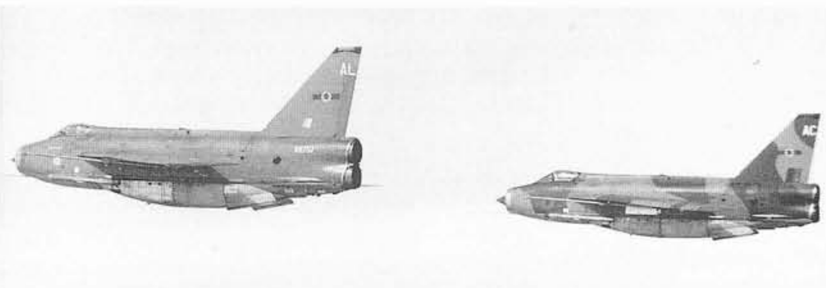
At the start of 1975, the fifteenth year of Lightning operational service, the RAF had six squadrons of the type. Nos.19 and 92 at Gütersloh had F.2As; all of the other four squadrons were equipped with F.6s, Nos.5 and 11 at Binbrook, No.23 at Leuchars, and No.56 at Akrotiri. No.56 Squadron returned to Britain in January 1975, moving into Wattisham. The run-down continued with No.23 Squadron disbanding in October 1975, and No.56 Squadron followed in June 1976. Both squadrons quickly reformed with Phantoms. In RAF Germany Nos.19 and 92 Squadrons disbanded in December 1976 and March 1977 respectively; again, both were reformed with Phantoms. By the spring of 1977 there were therefore only Nos.5 and 11 Squadrons left with Lightnings. These squadrons, both at Binbrook, were to continue operating the Lightning into the early 1980s.

Binbrook had become the home of the Lightning, for all training, maintenance and aircraft storage activities being concentrated there, along-

side the two active squadrons. As other squadrons had given up Lightnings, all the F.6s and T.5s, and the better F.3s, had gone to Binbrook. There they were used to equip the training flight, and form a large reserve for the active squadrons. Normally Binbrook had over seventy Lightnings, of which about thirty were with the flying units, the remainder being in storage or undergoing maintenance. Flying training at Binbrook was initially the responsibility of the Lightning Conversion Flight, which operated as C Flight of No.11 Squadron. In September the flight became the independant Lightning Conversion Unit. A year later the title changed to the Lightning Training Flight (LTF), which was destined to operate in support of Nos.5 and 11 Squadrons for the remainder of their time flying the Lightning.

Further consideration of its fighter requirements caused the RAF to conclude that more aircraft would be needed in the 1980s than previously anticipated. The eventual replacement for the Lightning (and the Phantom) was to be the Air Defence Variant (ADV) of the Tornado, but the ADV was not planned to enter service until the late 1980s. Assessments of the numbers of fighters needed in the 1980s produced the conclusion that there would be insufficient Phantoms, leading to the decision that Lightnings should continue in service until the late 1980s. By that time even the youngest F.6 aircraft would be 20 years old, and it was not known if the aircraft had sufficient fatigue life to remain in service for such a long time. It was therefore necessary to perform a full fatigue test on a specimen F.6 aircraft. Late in 1978 the prototype F.6, XP697, was withdrawn from storage at Binbrook and flown to Warton. After the lengthy process of rig building and commissioning was complete, British Aerospace began the test in mid-1980. The full original design life was reached in September 1981, and the test was completed in May 1983, when a fatigue life extension of about 30 per cent had been achieved.

The increase in fatigue life was sufficient to keep the Lightning in service up to the end of the 1980s, provided that the fatigue life of individual aircraft was not used at too high a rate. This was ensured by interchanging the active and stored aircraft at Binbrook at regular intervals. In 1979 the Ministry of Defence announced that a third active Lightning squadron was to be formed, although financial constraints did not, in the event, allow this to happen. However, the Lightning Training Flight was considered to



Two Lightning F.6s of No.5 Squadron in 1985 illustrate different standard paint schemes. The grey and green camouflage on AC (right) was superseded by the uniform mid-grey scheme on AL (left). (*British Aerospace*)

Lightning F.53 ZF592 (formerly 53-686 of the Royal Saudi Air Force) was one of ten aircraft that arrived at Warton on 22 January, 1986. They were parked out in open storage on the aerodrome, with the twelve that had arrived the previous week. Saudi markings were removed for the ferry flight to the United Kingdom, being replaced by British markings and serial numbers. (*British Aerospace*)

be a shadow squadron, which could become operational at short notice if necessary.

In October 1986 No.5 Squadron celebrated 21 years of Lightning operations. 1986 was the 25th anniversary of the Lightning first entering service, and the 32nd anniversary of the first flight of the P.1A research prototype. 1986 also marked 20 years of Lightning service in the Royal Saudi Air Force. However, the other export customer, Kuwait, had withdrawn the type from service in 1977.

Saudi Arabian Lightnings equipped Nos.2 and 6 Squadrons of the RSAF up to 1982, when deliveries of F-15 Eagles to No.6 Squadron began. The remaining active Lightnings, numbering about 25, were concentrated with No.2 Squadron at Tabuk. In 1985 Saudi Arabia reached an agreement with British Aerospace for the purchase of 72 Tornados, part of the deal being the trading-in to BAe of 22 Lightnings. These aircraft were flown back to Warton in January 1986, where they were placed in storage, available for sale, as most aircraft still had a useful amount of fatigue life remaining.

During 1986 the RAF announced that the Lightning would be withdrawn from service by mid-1988. However in 1986 over 60 aircraft were still in active service or storage at Binbrook. Although the type remained as popular as ever with its pilots, over the years it had become increasingly difficult to maintain. As a flying machine it was still very effective, but as a weapons system it was certainly obsolete. By 1987 about 20 Lightnings were preserved as museum exhibits or static display aircraft, and it is likely that this number will increase when the RAF aircraft are all finally withdrawn from service.

To be considered a success, an aircraft project must meet its technical requirements and achieve satisfactory sales. The Lightning was designed as

a specialised interceptor to meet a specific RAF requirement, which did not permit any compromises towards other roles. There can be no doubt that the aircraft was a highly effective interceptor, indeed it was widely considered to be the finest aircraft of its type in the late 1950s and 1960s. Thus the Lightning was undoubtedly a technical success. It could not, however, really be considered an unqualified commercial success. Orders for the RAF totalled 286 aircraft, and exports added a further 54, bringing total production to the modest figure of 340. The limited home market meant that a more substantial production total could only be achieved by greater export success. The principal competitors for the Lightning in export markets were the F-104 Starfighter, the F-4 Phantom and the Mirage III. Export sales of these three types during the 1960s totalled about 2,900. With only 54 sold for export, the Lightning clearly did not obtain a reasonable share of the potential market. Total production was therefore well below what it might have been.

The main reason for the shortage of export sales is fairly obvious. Most potential customers required a multi-role fighter, not a pure interceptor such as the Lightning. Although a multi-role Lightning was eventually developed, it was not available until 1964. In contrast, the three main competing types were all on offer as multi-role fighters by the late 1950s. This was in spite of the fact that, like the Lightning, all three types had originally been designed as interceptors. If the multi-role Lightning had been available earlier the prospects for export sales would have been greatly improved. However, the type would still have suffered from the

After Lightning F.1A XM172 was withdrawn from use with 226 OCU, it was placed on display near the main gate at RAF Coltishall. (*British Aerospace*)

political and economic difficulties which were an extra hindrance to sales in some markets.

The case of the Lightning is an object lesson in modern fighter design. No matter how brilliant the design may be, if the basic specification is too restrictive, then the resulting aircraft will probably have seriously restricted sales potential. However, in the case of the Lightning this fact does not detract from the credit due to the team which produced a superb technical solution to the specification defined by the customer. In this respect the Lightning was a true thoroughbred, and a worthy successor to the Canberra.

P.1A research aircraft and Lightning F.1, F.3, F.6, F.53. Powerplant: P.1A: two 8,100 lb st 10,3000 lb st with reheat, Armstrong Siddeley Sapphire Sa.5; F.1, F.1A, F.2, T.4: two 11,250 lb st, 14,430 lb st with reheat, Rolls-Royce RA.24R Avon Mk 210; F.3, T.5, F.6: two 13,220 lb st, 16,300 lb st with reheat, Rolls-Royce RA.34R Avon Mk 301; F.53, T.55: two 11,100 lb st, 16,300 lb st with reheat, Rolls-Royce RA.34R Avon Mk 302C.

	P.1A	F.1	F.3	F.6	F.53
Span	34ft 10in	34ft 10in	34ft 10in	34ft 10in	34ft 10in
Overall length	56ft 8in	55ft 3in	55ft 3in	55ft 3in	55ft 3in
Height	17ft 3in	19ft 7in	19ft 7in	19ft 7in	19ft 7in
Empty weight	21,000lb*	25,000lb*	25,000lb*	25,000lb*	25,000lb*
Maximum loaded weight	28,000lb*	35,000lb*	35,000lb*	45,000lb*	50,000lb*
Maximum Mach No. at high altitude	1.5	2.0*	2.2*	2.2*	2.2*
High speed cruise	—	595mph	595mph	595mph	595mph
Initial rate of climb	—	50,000ft/min*	50,000ft/min*	50,000ft/min*	50,000ft/min*
Time to 40,000ft	—	2min 30secs	2min 30secs	2min 30secs	2min 30secs
Service ceiling	—	60,000ft+	60,000ft+	60,000ft+	60,000ft+
Typical endurance	0hr 50min*	1hr 15min*	1hr 15min*	2hr 00min*	2hr 00min*

*Approximate figures.

Armament and stores carried:

F.1, F.1A, F.2: Two 30 mm Aden cannon built in to fuselage; weapons pack with two Firestreak air-to-air missiles, or 44 two-in rockets, or two 30 mm Aden cannon.

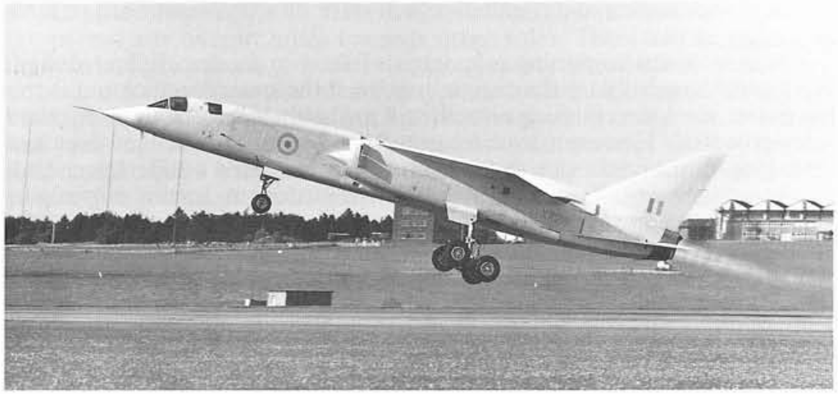
F.2A: As F.2, plus two 30 mm Aden cannon in ventral pack.

T.4: Weapons pack options as F.1, no built-in cannon.

F.3, T.5, T.55: Weapons pack with two Red Top air-to-air missiles, or two Firestreak missiles, or 44 two-in rockets.

F.6: As F.3, plus two 30 mm Aden cannon in ventral pack.

F.53: As F.6, plus multi-role stores. Weapons pack may be replaced by reconnaissance pack with five Vinten cameras or electronic equipment. Under-wing pylons can carry total of four 1,000 lb bombs (ballistic or retarded), or four MATRA rocket launchers each carrying eighteen 68 mm air-to-ground rockets, or four flare pods. Over-wing pylons can carry total of two 1,000 lb bombs (ballistic or retarded), or two MATRA rocket launchers each carrying eighteen 68 mm rockets.



TSR.2 takes off for its first flight, from A & AEE, Boscombe Down, on 27 September, 1964. *(British Aerospace)*

British Aircraft Corporation TSR.2

The eventual need for a Canberra replacement was recognised by English Electric relatively early in the life of that aircraft and some time before the issue of the official requirement. In fact, a replacement was first briefly considered early in 1953, the single surviving drawing of it depicting a supersonic, mid-wing aeroplane with jet engines buried in the wing roots. Serious official consideration of a replacement during 1956, however, led to renewed interest by the company in the project and to preliminary exploratory discussions with the Ministry of Supply. The first of these meetings took place early in October, during which it became evident that official thoughts were of a Canberra replacement in terms of a small fast fighter-bomber to be developed from then current strike-fighter proposals. The Ministry, however, thought that these proposals were inadequate in range and speed for bombing and other roles, and suggested that the developed strike-fighter should have a radius of action of at least 350 nautical miles at sea level and be capable of speeds up to Mach 1.3 in the target area, the latter requirement being intended to reduce the aircraft's vulnerability during an attack. At this juncture the discussion turned to the possibility of developing the P.1B (as yet unnamed) to have the desired performance and the company agreed to examine this variant, but pointed out that the requirement could certainly be met with a new aircraft which could be considered a more genuine Canberra replacement.

Subsequently, plans were made in the project office at Warton to investigate both the company's own ideas of a suitable replacement on a private venture basis and the development of the P.1B, under the designations P.17 and P.18 respectively. In considering the P.17, the company bore in mind from the outset the factors which had led to the success of the Canberra. These qualities were flexibility in operational roles and performance and the adoption of a simple conventional airframe incorporating current aerodynamic and structural design knowledge but

having no very advanced features conducive to delays in its development. Although unconventional layouts, giving possible marginal improvements in performance, were to be considered, it was realised that the high degree of technical risk involved in their development would probably lead to unacceptable in-service dates. These schemes, therefore, were regarded as secondary in importance.

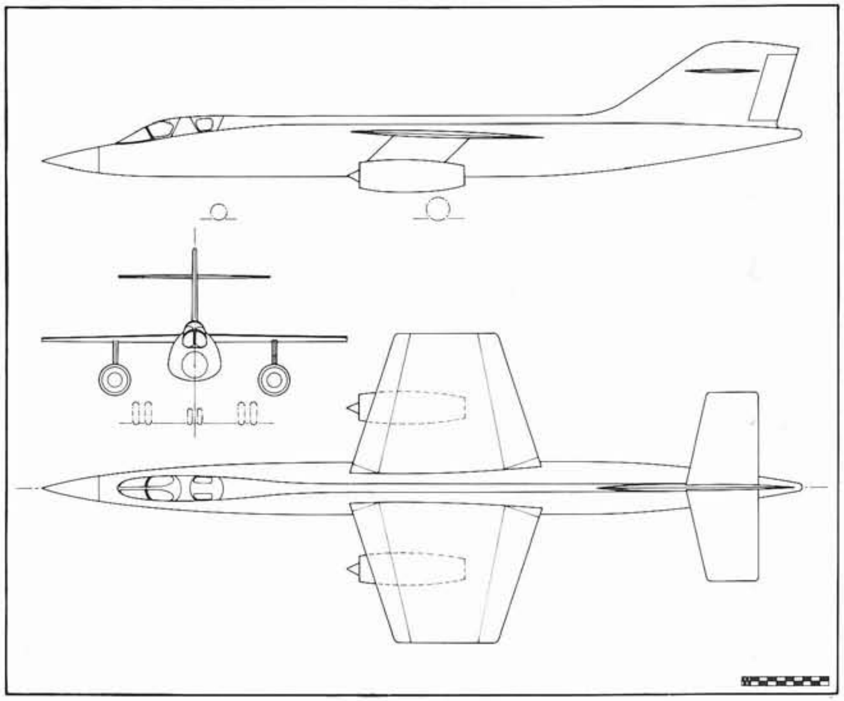
One of the RAF's basic requirements was for an aircraft capable of attacking at low altitude and at high speed. Under these operating conditions it was known that the aircraft and crew would be more subject to turbulent air or gusts than at any other part of the aircraft's flight envelope. In general, the effects of tubulence resulted in a shortening of the fatigue life of the airframe and equipment, a reduction in crew efficiency and a deterioration in the aircraft's handling qualities. Therefore, the need to provide a controllable aircraft which would have a minimum response to gusts so that the crew could work in comfort and navigate and deliver their weapons accurately, became a prerequisite of any design to fulfil the RAF's requirements. At the time English Electric began its studies there was little information available on this operational aspect and reliance had to be placed on extrapolations of data from other sources, in particular by comparing the performance of a number of aircraft which had been flown in low altitude turbulence. The comparisons enabled the company to judge a particular configuration's reponse to gusts and to determine a maximum vertical acceleration which the crew could comfortably endure in turbulent conditions. It was known that the acceleration due to a gust was directly proportional to air density, aircraft speed and an aerodynamic quantity known as the lift curve slope, and was inversely proportional to wing loading. From the relationship of these quantities, it was apparent that at low altitudes air density and the required high speed were contributing towards the crew's discomfort and the only factors which the designer could influence to produce an aircraft with minimum gust response were the lift curve slope and the wing loading. Of the last two variables, wing loading noticeably affected low-speed performance, particularly take-off and landing distances, and therefore the value selected was necessarily a compromise between that needed for operations from short runways and for minimising gust response. A moderately high wing-loading was considered to be the optimum. Consequently, a significant contribution to crew comfort was the reduction in lift curve slope, achieved by choosing a wing with the lowest practicable aspect ratio. The lift curve slope could be further reduced by making such a wing highly swept. The chosen aspect ratio was a compromise between a number of inter-related aerodynamic and structural factors. An aspect ratio of about two was considered to be the optimum.

The choice of wing planform and tail arrangement resulted from the earlier work on a cheap Canberra replacement done mainly by R.F. Creasey, later director of engineering. A comparison of various wings was made, for example, using a parameter which related gust responses to a given take-off distance. The comparison indicated that delta wings were superior to trapezoidal and swept wings. It was thought, however, that trapezoidal wings with leading-edge flaps could generate more lift and work proceeded using this planform for preliminary studies.

Two configurations based on sketches drawn on 19 October, 1956, by

B.O. Heath (then chief project engineer) and considered to represent extremes in conventional construction were to be investigated. The first sketch was of an aircraft with a shoulder-mounted straight equi-tapered wing, two podded engines suspended below the wing, and a long slender fuselage seating the crew in tandem behind a nose-mounted radar, and having a bomb-bay and fuel tanks arranged amidships like those of the Canberra. The rear of the fuselage was left free for equipment and in particular for the scanning aerials required for electronic reconnaissance. The tail surfaces were conventional, with the tailplane mounted mid-way up the fin. A bicycle undercarriage stowed in the fuselage with outrigger wheels carried in the engine nacelles was envisaged. The second sketch showed an aircraft of canard layout, this arrangement undoubtedly originating from earlier work on the P.10 (see under English Electric in Appendix C). The two engines in this design were positioned close together and side-by-side in the extreme rear of the fuselage, below the shoulder-mounted wing, and had their intakes located on either side of the fuselage and slightly behind the wing leading-edge. A straight wing planform was adopted for this aircraft also and it had highly-swept foreplanes.

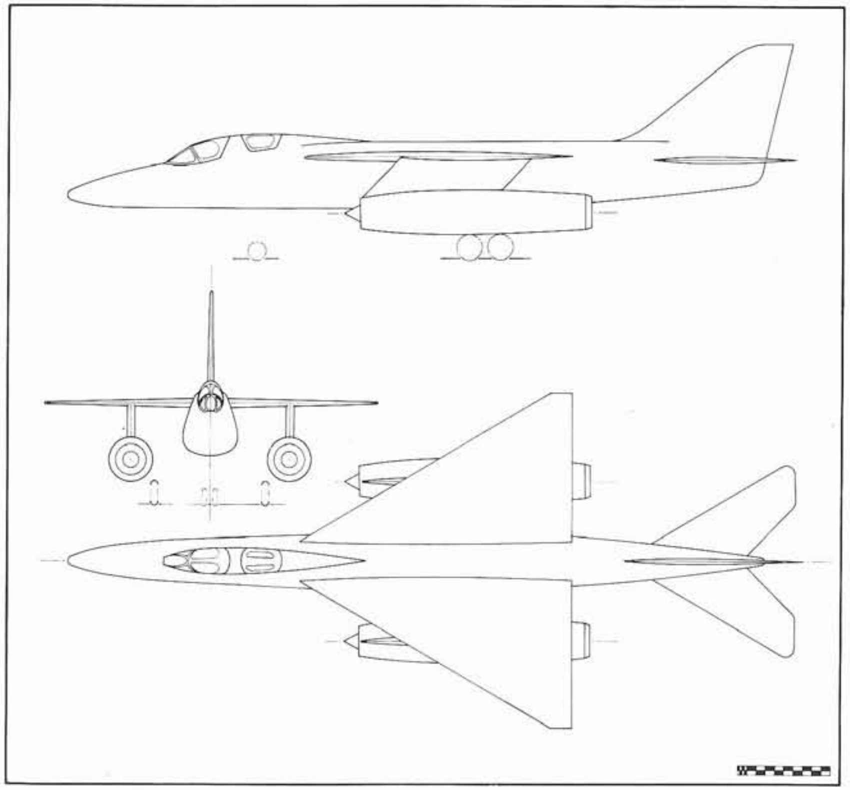
At the beginning of November, however, the Ministry, after further discussions with the Air Staff, was able to give a clearer indication of the RAF's requirements. These now transpired to be for an aircraft with a radius of action of 1,000 nautical miles flying at a speed of Mach 1.5 at



English Electric P.17 (December 1956).

altitude, a radius of action of 600 nautical miles flying transonically at sea level with a dash speed capability of up to Mach 1.3 over the target area and a ferry range of 2,000 nautical miles. The aircraft was to carry a variety of weapons together with photographic and electronic reconnaissance equipment and was desirably to take-off vertically. On receipt of this information the project team at Warton was able to begin checking its preliminary performance analysis based on the P.17 and P.18 configurations against the RAF's requirements. The engine initially selected for this work was the Rolls-Royce RB.133, a projected development of the Avon. Later, this engine was to be superseded for performance calculations and for design work by the RB.142 and the Bristol Olympus B.O1.14R.

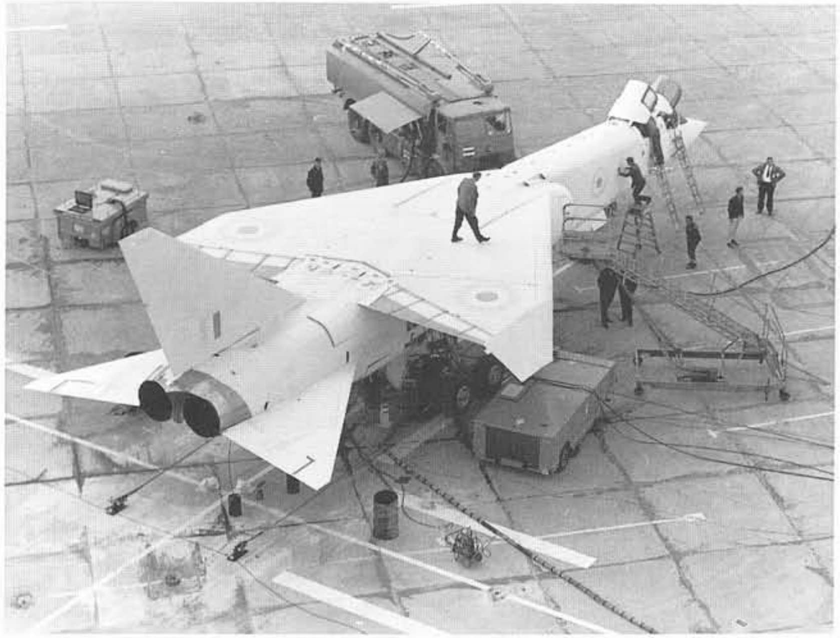
A vital adjunct to this work was the start of what was to prove an intensive wind-tunnel test programme. The initial tests, which began in December 1956 and continued through until the following February, using models of the conventional and canard configurations established the basic features of the P.17. Towards the end of this period a delta wing having a leading-edge sweep of 60 degrees and a single-slotted flap was also tested. The results obtained from the model of the conventional aircraft resulted



English Electric P.17 (January 1957).

in the engines being installed in the fuselage to decrease drag and improve lift and a low-set tailplane to achieve satisfactory longitudinal stability. At that time the delta wing showed no particular advantage over the trapezoidal wing and the latter was therefore retained as the baseline. The canard layout was found to require a centre of gravity so far forward of the wing aerodynamic centre that the foreplanes could not trim the aircraft satisfactorily when the flaps were up and not at all when the flaps were down. This result led to the immediate abandonment of the canard layout. Thus in January 1957, general arrangement drawings of the P.17 showed an aircraft with a straight equi-tapered wing, two RB.133 engines incorporated side-by-side in the rear of the fuselage with their intakes below the wings, and a low-set tailplane. To denote the departure from podded engines the aircraft was redesignated P.17A. Continued testing during February with the delta wing, however, was beginning to reveal more favourable results at low speeds. The company knew from P.1B experience that proper shaping of a highly-swept leading-edge could give unusually low drag, compared with other thin low-aspect ratio wings, both for subsonic cruising and supersonic speeds. It was known also that such wings were desirable to minimise response to gusts and ensure good handling qualities at high subsonic speeds. Therefore, the decision was made to proceed with the design of P.17A with a delta wing.

Meanwhile arrangements for a second series of tests in the high-speed tunnel were being completed. These were to provide preliminary data on



Preparations for engine runs of the first TSR.2 at Boscombe Down, May 1964. (*British Aerospace*)

the effects of wing planform on longitudinal stability characteristics at transonic and supersonic speeds. Testing began in January and continued until October 1957. The results demonstrated the superiority of the delta wing.

During January 1957 further discussions took place between representatives of the Ministry of Supply and English Electric and for the first time at these meetings high-ranking RAF officers of the Air Staff were present. The discussions revealed that the requirement for a Canberra replacement had become more urgent and more defined. The aircraft was to perform a strike and reconnaissance role, have a crew of two and carry at least four, preferably six, 1,000 lb bombs and other weapons and stores making up a similar total weight. Range and speed requirements remained more or less the same as previously indicated but there was considerable emphasis placed on the aircraft's ability to perform large parts of a sortie at very low level. Operations were to be made from a maximum runway length of 3,000 ft, though even shorter take-off runs were desired, and from prepared surfaces. Preference for vertical take-off was again intimated. Naturally, the P.17A's ability to meet these criteria was discussed and from what was said it was apparent, even from the company's limited studies, that the P.17A was going to become a viable proposition. Progress of its counterpart, the P.18, was also reviewed but it was clear that this and other fighter-bomber proposals were not going to meet the operational ranges and associated aerodrome performance demanded by the RAF. Consequently, it was agreed that work on the P.18 should cease and that the company should concentrate its efforts even more on the P.17A. It was also made known that the aircraft would be required in service in 1964. This timescale was considered by the company to be too short for the development of what was emerging as a complex aircraft and warned the RAF that the timescale ruled out consideration of vertical take-off and any formal preparation of a requirement followed by a prolonged design competition.

The next few weeks saw the project team at Warton preparing a note outlining the company's thoughts on the subject of a Canberra replacement based on the work leading to the delta-winged P.17A. The report was 'published' on 19 February, 1957, and copies of it were sent to the Ministry to be studied in official circles. In the report the company maintained that there was still a strong case for retaining manned aircraft in an era of missiles. An aircraft, it was argued, could be used with discretion and had the flexibility of deployment and armament necessary to wage war in tactical scenarios. Thus, there was still a requirement for an aircraft to replace the Canberra in its many roles. The company, however, readily appreciated that any new project would have to be considered carefully in the light of the prevailing economic situation but felt that if Canberra and P.1B experience was fully exploited, development costs should be reasonable. In addition, the company thought that if emphasis on flexibility was maintained and costs were not excessive—factors leading to the Canberra's success—appreciable foreign sales could accrue which would assist the country's balance of payments and lead to recovery of the development costs. The report went on to discuss various aspects of the aircraft's operation and highlighted areas of high risk in the development of an aircraft to meet the RAF's requirements. It concluded that it was

The prototype TSR.2, XR219 undergoing ground testing at Boscombe Down. The nose undercarriage is in the extended position and the bomb-bay doors are open. (*British Aerospace*)

possible to produce an aircraft with both low-level transonic and high-altitude supersonic performance, with a range considerably extended by subsonic cruising, and with the ability to carry a variety of weapons and equipment.

While work proceeded on the P.17A, events, which were to have a significant effect on the aircraft industry generally, were taking place. On 18 January, 1957, the House of Commons Select Committee on Estimates presented its report to Parliament on the supply of military aircraft. Among the recommendations listed, three items were particularly relevant to the project under consideration: first, that the RAF should consider the possibility of accepting delivery of early versions of an aircraft, even though these might not completely fulfil the operational requirement, and using them pending production of later modified marks. This measure accorded with English Electric's thoughts on the P.17A; second, that steps should be taken, with the agreement of the industry, to limit the number of firms receiving Government contracts for airframes and engines; third, that the Ministry of Supply should use the selective allocation of contracts to bring about a 'measure of coalescence' in the aircraft industry. The last two points were to herald the start of rationalisation within the industry. On 24 January, 1957, Duncan Sandys, who had been Minister of Supply from 1951 to 1954, was appointed Minister of Defence in the then Conservative Government. Within a few days of taking office he met his opposite number in Washington for discussions. It was rumoured that one of the topics they were to consider was the purchase of missiles from the USA. Subsequently, there was a great deal of speculation and heated argument as to whether there was a role for manned aircraft in a war fought with missiles. On 4 April, 1957, Sandys presented the White Paper on Defence, which included the omnious paragraph:

'Having regard to the high performance and potentialities of the Vulcan and Victor medium bombers and the likely progress of ballistic rockets and missile defences, the Government have decided not to go on with the development of a supersonic manned bomber which could not be brought into service in much under ten years.'

This statement, considered in retrospect, was widely misinterpreted because it was later revealed that the aircraft referred to was the Avro 730. However, the apparent ambiguity contained in it also led many to believe that there would be no more manned bombers. This belief was contrary to the situation then developing, because the first draft of General Operational Requirement No.339 for a supersonic tactical strike and reconnaissance aircraft to replace the Canberra had been completed by the Air Staff on March 26. A consequence of these almost simultaneous events was that the GOR became the subject of much criticism and argument, which delayed its issue.

The Ministry of Supply had proposed to circulate GOR 339 to the RAE and several companies before the end of the month for initial assessment and as a basis for design and planning investigations. The work was to be completed by the end of the following July. By the end of March, however, though preliminary estimates of the design capacity of various firms to undertake the contract had been made, no final decision had been reached on the form of a design competition and the GOR had still to be officially circulated.

While awaiting the issue of the GOR, English Electric began intensive wind-tunnel testing of the P.17A and, therefore, was able to develop the airframe from the aerodynamic standpoint and to investigate in depth various design features of the airframe and systems and thereby isolate and find solutions to certain problem areas. By September 1957 the work was well advanced and this was to give the company an advantage during the next phase of the project. The company's position was further enhanced as a result of its input to the earlier discussions with the MoS and the Operational Requirement Branch of the Ministry of Defence during the formulation of the GOR, of which the company had seen an early draft.

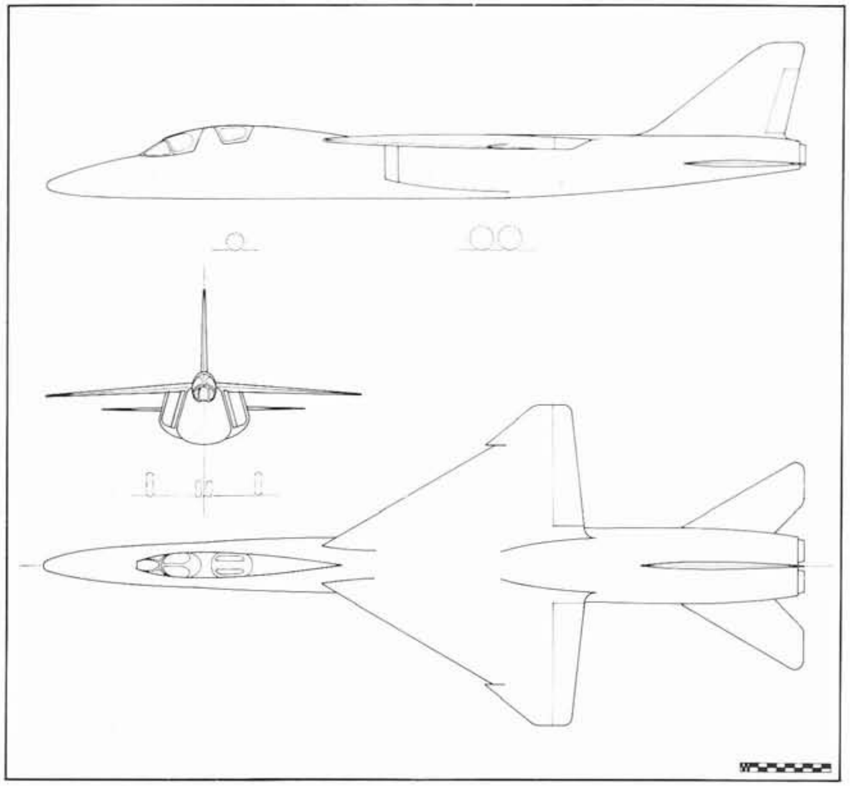
During this period (May to December 1957) the aircraft was to undergo two major changes in configuration, the result of wind-tunnel tests and further detailed design investigations made by the project and aerodynamics offices. These were the incorporation of blown flaps and vertical fixed-ramp intakes instead of the quarter cone-type initially conceived and based on P.1B experience. Thereafter, no other changes were made apart from those refining the design. Before the end of the year the fixed-ramp system gave way to a movable one so that intake performance could be more easily optimised for both subsonic and supersonic flight conditions.

GOR 339 was issued to the industry late in September 1957 and submissions to it were invited from most of the major companies. The resulting proposals were to provide the basis for the selection of the company to undertake the contract. However, only Bristol Aircraft, Avro, Hawker Aircraft, Vickers-Armstrongs (Aircraft) and the English Electric Co in association with Short Bros & Harland were to prepare detailed proposals. These they formally presented to the Ministry of Supply in January 1958. The very short time allotted to undertake the somewhat exacting feasibility study, generally did not allow it to be investigated in

depth although all the participating firms naturally were able to evolve designs, some of them based on current projects, which embodied to varying degrees the main requirements specified in the GOR. The English Electric-Short Bros submission, not unexpectedly proved to be the most detailed and as far as can be ascertained, was the only one which attempted to provide a complete solution to the GOR and, in particular, to comment on the VTOL requirement.

Collaboration between English Electric's and Shorts' project design teams had its origin in the working relationship established in connection with Shorts' sub-contract production of various marks of Canberra. This, together with Shorts' growing experience in the VTOL field with the SC.1, although at that time neither of the two SC.1 prototypes had begun hovering trials, made a joint venture seem natural. Moreover, co-operation between the two firms was in accord with the Government's plans for consolidation of the aircraft industry. The prospect of a complete merger, however, did not last long, the companies' collaborative effort ending soon after the submission date. Short Bros was to be responsible mainly for the V/STOL studies whilst English Electric was to continue to concentrate on the P.17A. The English Electric-Shorts proposal was based on the argument that it was not possible to develop an aircraft with VTOL capability in the timescale set out in the GOR, but that by divorcing the VTOL aspect the RAF could have the type of aircraft it wanted with the ability to operate from short runways within the time specified. The compromise therefore proposed that the RAF should initially accept a conventional form of aircraft with which it could obtain the relevant experience and later employ a separate piloted VTOL platform capable of launching and retrieving the conventional aircraft. The platform would use the practical experience about to be gained with the SC.1. The platform, designated P.17D by English Electric and PD.17 by Shorts, was a slender-delta flying-wing weighing some 47,000 lb, which housed 56 Rolls-Royce RB.108 lift engines and a number of propulsion engines to provide it with forward motion whilst launching and retrieving the P.17A carried on its back. The companies also envisaged a freighter role for the P.17D to provide all the support necessary for the maintenance and operation of the P.17A. It was believed that the platform could be developed to a sufficiently high degree of reliability by the time the pre-production P.17A

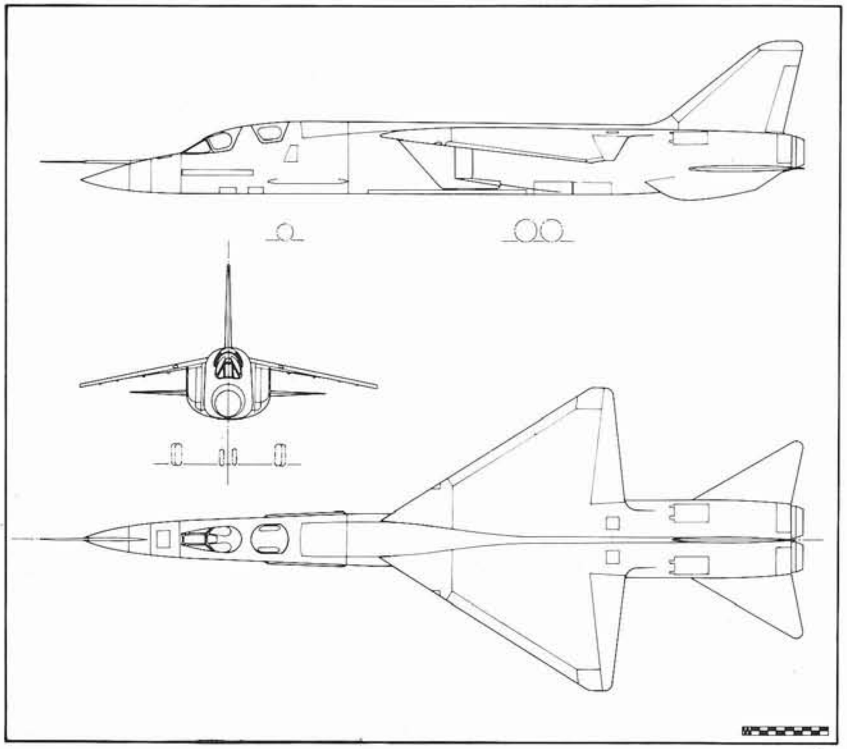
TSR.2 landing after a successful first flight. (*British Aerospace*)



English Electric P.17A (October 1957).

was ready for flight trials. Ultimately, when adequate operational experience with the combined aircraft had been gained it was proposed to dispense with the P.17A's undercarriage and flaps and to increase its wing loading so that a much greater radius of action at sea level could be obtained together with longer endurance at supersonic speeds.

The English Electric-Shorts submission filled three thick volumes. The first two outlined the evolution of the P.17A and gave a very comprehensive aerodynamic and technical description of the airframe and its systems, together with relevant data from the companies' wind-tunnel testing and other sources substantiating the firms' claims and calculations, and a discussion on how the aircraft might be used during the mission specified in the GOR. A factor worthy of note determined during the evolutionary stage was that relating to the size of the P.17A's engines. English Electric considered that development of either the Bristol Olympus or the Rolls-Royce RB.142 would be necessary to achieve the fuel economy required to fly the specified sorties and the high thrust needed to meet the take-off performance stipulated, and pointed out that these could not be reduced significantly without some relaxation of the GOR. In the event English Electric's conclusion regarding engine development was to prove



English Electric P.17A (January 1958).

right. However, the Olympus selected for the TSR.2 was rather more than a progressive development, it was a new engine.

The third volume of the joint submission dealt with unconventional means of meeting the GOR and included proposals for a variable-geometry version, an aircraft fitted with a variable-camber wing (the changes in camber being achieved by means other than the use of slats and flaps) and a truly VTOL aircraft, which served to demonstrate the impracticability of pursuing this operational benefit using the then current knowledge and experience. These unconventional designs, although offering marginal advantages, introduced a number of new problems, which would have required a considerable amount of technical investigation to show which design was superior. Because of the relatively short time remaining to introduce the new aircraft into service, English Electric preferred to work using then current technology to ensure meeting the timescale. The alternative designs meant taking technical risks that could have delayed the in-service date by years.

The assessment of the various submissions by the Ministries of Supply (shortly to be renamed Ministry of Aviation) and Defence was not completed until June 1958 but an initial appraisal had led to the publication in March of a report on which companies had been selected,

namely, Avro, Hawker Aircraft, Vickers-Armstrongs, and English Electric. At about this time also a strong official recommendation was made to each of the companies to co-operate with any one or all of the other firms in any commonly agreed manner and to re-submit a joint proposal. This recommendation was clearly intended to be a step in the implementation of the Government's policy of consolidation of the industry. Hawker Aircraft and Avro both being members of the Hawker Siddeley Group naturally chose to collaborate. The absence of Shorts' name from the list of chosen firms therefore tended to suggest a merger between Vickers and English Electric, which was not quite as natural and in the event was not so readily achieved. The subject of collaboration was broached by Vickers during April 1958, and initial discussions were little more than an exchange of brochures outlining their proposals and an exchange of views on the equipment to be installed in the aircraft. Shorts was never again to participate in the project and its disappearance from the scene is largely believed to be attributed to official circumspection of VTOL proposals in general. Unfortunately, English Electric's project without the radical P.17D appeared very conventional when compared with the other submissions and the P.17A was consequently criticised (not only by officialdom) for being insufficiently advanced technologically. The fact that the P.17A had been evolved on a probably more sound basis than the other proposals (attributable to English Electric's extensive private venture work and supersonic experience) and could more likely have been made in the required timescale, seem to have been the decisive factors in silencing the P.17A's critics and leading to the company's selection as one of the major contenders.

In the meantime, the first draft of a more definitive specification, based on the original GOR and updated by the preliminary assessment of the feasibility studies, was issued in February 1958. Known as Operational Requirement (OR) 339, it was to be redrafted and re-issued no less than four times before the end of the year, on every occasion becoming more demanding overall. It subsequently underwent further revision and in March 1959 was renumbered and published as OR 343. It may be mentioned in general terms that the changes to the specification most affecting the aircraft's design during this period were: increase in penetration speed and speed at altitude; a shortening of take-off distances demanding more thrust; the ability to land in higher cross-winds requiring more control during the approach and landing; operations from less hard,

XR219 taxi-ing before its first flight. (*British Aerospace*)

semi-prepared surfaces necessitating larger diameter low-pressure tyres for the undercarriage; an increase in ferry range needing extra fuel and a decrease in the altitude at which the aircraft was to penetrate enemy defences leading to more advanced and highly reliable control systems. Some requirements, however, remained little altered but nonetheless imposed severe demands on airframe and equipment, for example: flight at sustained supersonic speeds both at low and high altitudes which necessitated good fuel consumption at high thrust, and the use of materials able to withstand the strength reducing and creep inducing effects of kinetic heating at these speeds, and pin-point navigational and bombing accuracy which required complex equipment including miniaturised digital computers. The resultant effect of all these requirements was that the aircraft grew in size and weight.

The Ministry of Supply completed its assessment of the four contenders' proposals in June 1958. The result favoured a partnership between Vickers and English Electric, although the two companies still had not made a serious attempt to produce a common design. It was to be mid-November before the first joint discussions at technical level were to be held at Weybridge. Until then both companies continued to develop their respective projects independently, English Electric concentrating on the integration of airframe, equipment and systems; stability investigations; flap development, and intake design.

In October 1958 English Electric thought it necessary for commercial reasons to apply for a patent covering the P.17A's configuration. The complete patent specification, No.873,679, was not published because of security restrictions until July 1961. The application was made on behalf of the configuration's earliest inventors, R.F. Creasey, B.O. Heath and G.F. Sharples, the project design engineer responsible for the initial scheming of the layout. The patent, besides briefly outlining the aerodynamic and performance criteria which determined the aircraft's configuration, revealed several technical features relating to the P.17A's layout, some of which were to be incorporated in what was to become known as the TSR.2.

The first public acknowledgement of the existence of the project was made on 17 December, 1958, in a written answer by George Ward, Secretary of State for Air, to a question raised in the House of Commons by Geoffrey de Freitas. It simply stated that the Government had decided 'to develop a new strike/reconnaissance aircraft as a Canberra replacement. This will be capable of operating from small airfields with rudimentary surfaces and have a very high performance at all levels.' A further statement amplifying the reply was made on 1 January, 1959, by Aubrey Jones, Minister of Supply. The Parliamentary statement he made said that subject to satisfactory negotiations the new aircraft, to be named TSR.2, 'would be undertaken jointly by Vickers-Armstrongs and English Electric, the main contract being placed with Vickers-Armstrongs and work being shared between the two companies on a fifty-fifty basis. A joint project team drawn from both companies is being established at Vickers' works at Weybridge for the execution of the project.' The report continued: 'Subject equally to satisfactory negotiations, the development of the engine for the new aircraft will be undertaken by Bristol-Siddeley Engines, the new company formed out of Bristol Aero-Engines and Armstrong Siddeley Motors, subsidiaries respectively of the Bristol

An early flight of TSR.2 before attempts to retract the undercarriage. Note the strong wingtip vortex. *(British Aerospace)*

Aeroplane Company and the Hawker Siddeley Group. Both these engine companies have indicated that they are now proceeding to a complete financial integration.'

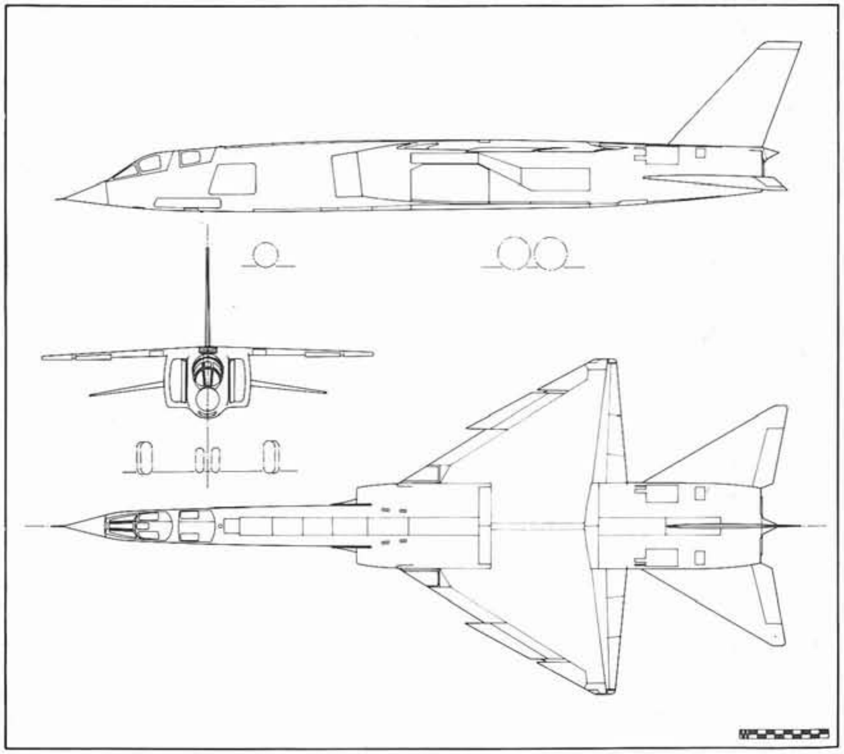
This occasion also was the first time in public that the aircraft was referred to by the name TSR.2, which, it is believed, was originated in official quarters to denote its roles and speed of Mach 2.

The initial technical discussions at Weybridge in November 1958 began with a critical mutual assessment and a comparison of the merits of the two companies' projects to determine how the best features of each could be merged to produce a common design. In order to facilitate this an agreement was made whereby English Electric undertook the evaluation of all aerodynamic data applicable to the two designs and Vickers examined the overall weapons system. These assessments were completed by the end of the year and on 1 January, 1959, the firms were ready to proceed with the design of TSR.2.

Vickers' aircraft at that time was in many respects more advanced than English Electric's, particularly in regard to the design of the airframe and systems, but was not quite as developed aerodynamically. Vickers' contribution to the merger was evolved by the Vickers-Supermarine project team and was the twin-engined development of the single-engine aircraft initially submitted to the MoS in January 1958 in response to GOR

339. The twin-engine version was more in accordance with Vickers' ideas on what was required to meet all aspects of the specification and not unexpectedly was larger and more complex than its other proposal. Vickers-Supermarine's design was shorter and of larger span than the P.17A and was about the same all-up weight but had a smaller wing area and therefore a higher wing loading. The wing was shoulder-mounted, moderately swept and tapered, had an aspect ratio of about 3.7 and was fitted with slats and slotted flaps. Wingtip fuel tanks were also carried. The slim area-ruled fuselage was similar in layout to the P.17A but the intakes were placed well forward of the wing leading-edge and the main undercarriage retracted forwards. The intakes were of the vertical reflected-shock type. The all-moving tailplanes were not as low set as those of the P.17A and had pronounced anhedral. The fin too was all-moving and a parachute was stowed in a fairing at its base.

The first major decision affecting the joint design was made on 1 January, 1959, and was the selection of the delta wing. The initial assessment had revealed that the two wing planforms considered were equally likely to attain the desired aerodynamic characteristics but that the delta wing had the better gust response and transonic handling characteristics. In addition, there was extensive data available on the delta



Vickers-Armstrongs/English Electric Type 571 (July 1959).

wing as a result of the wind-tunnel testing of the P.17A. Therefore, because the general features of the companies' individual projects were similar, it was further agreed that the P.17A wing, together with its blown flaps, should be grafted onto the Vickers project and the resultant design be used as the datum aircraft, which was to be given the Vickers-Supermarine designation Type 571 that had been originally used by Vickers for both the aircraft described in its submission to GOR 339.

Before the companies actually started work, the operational requirement (at that time OR 339, fourth draft, issued on 29 December, 1958) was re-examined. The increases in quantitative performance demands noted during this reappraisal led to a further decision, taken on 26 January, to consider a 'rigid' datum aircraft in order to obtain the best answer to the OR by giving priority to meeting the main requirements. Where these imposed conflicting demands on the airframe, engines and equipment, any gains resulting from compromises in the design were to be used in enhancing supersonic capability or future flexibility, for which Vickers and English Electric respectively thought that they should be used.

The work which followed was essentially a detailed engineering analysis of the Type 571. By the end of February 1959, the joint project group based at Weybridge had completed its initial object of refinement of the fuselage layout. A feature of the TSR.2 adopted at that time was the type of engine installation in which each individual powerplant was completely enclosed in a tunnel-type structure. The engines and jetpipes were withdrawn rearwards along rails inside the tunnels. Rapid progress was made the following March in evaluating the various features of the aircraft. Particular aspects examined were longitudinal stability, engine intake location, and the type of main undercarriage, which was chosen to retract forwards. Towards the end of March, however, English Electric expressed concern at the emphasis being placed on meeting the quantitative performance demands of the OR. The company thought that there was insufficient lattitude in the design to meet any contingency which might arise and to endow the aircraft with the measure of operational flexibility required for future development. These opinions, based on the company's past experience, were again about to be proved right. A few days later, on 26 March, the final draft of OR 339 was issued under its new nomenclature of OR 343. There was no relaxation in its demands, rather they were slightly more stringent in certain areas. A little later still, after discussions with tyre manufacturers, a recommendation was made to increase the size of the tyres for the main undercarriage to meet the required rudimentary surface performance, which created further difficulties in stowing them in the space available. Early in May more definitive data of the expected performance of the Bristol-Siddeley Olympus engines was issued, giving higher values of specific fuel consumption than had been allowed for in performance calculations. This had a serious effect on the aircraft and placed the companies in a quandary as to whether they should continue with the design as before in the hope that the original figures would eventually be achieved or cater for the higher values in order to verify the performance of the aircraft during development trials. The companies and the Ministry thought that any decision taken should err on the pessimistic side since it was considered essential to prove the aircraft's performance as soon as possible. Inevitably, after all these factors had been taken into

A potential enemy's view of TSR.2 at low level. Photograph taken on 6 February, 1965, during a fast flight over Boscombe Down. (*British Aerospace*)

account, the aircraft grew larger and heavier. However, even though the aircraft then apparently catered for all requirements, there was still concern expressed not only by English Electric but also by Vickers and the MoS that any future growth in weight would result in an aircraft which was not capable of the required performance. At this juncture an even more rigorous weight control programme was established, and means of reducing weight were considered, in particular, by the extensive use of integrally-stiffened machined components in the construction of the airframe. In addition, the latest aluminium alloys, which exhibited higher strength to weight ratios than those more commonly employed, were examined and used for the parts of the airframe where the most significant savings in weight could be made. These measures proved quite successful.

Towards the end of July 1959, Vickers and English Electric submitted the first brochure describing their jointly agreed datum aircraft to the MoS. At that time the main features of the TSR.2 were clearly recognisable and were to alter little during the next phase of the project. The fuselage was divided, for convenience of description in the brochure but later for manufacturing purposes, into four major zones, termed front, forward centre, aft centre and rear. The nose fuselage contained the forward-looking terrain following and sideways-scanning navigation radars; the pilot and navigator in separate tandem cockpits; the main avionic equipment and systems bays immediately behind the cockpit, and the twin-wheel nose undercarriage which retracted rearwards into the bay below the No.1 fuel tank. The cockpits and radar and main equipment bays were

pressurised and environmentally conditioned. The crew were provided with ejector-seats and the pilot had a head-up display, a then new flying aid, which gave him all essential flight and attack information in the form of symbols focussed at infinity on the windscreen. The forward centre fuselage was relatively short and was flanked by the intakes. Its upper region was occupied by part of No.2 fuel tank and its lower by bays for the doppler radar, inertial navigator, retractable ram-air turbine for the generation of electrical power in an emergency and other systems.

The much longer aft centre section embraced the remainder of No.2 fuel tank which lay between and over the engine intake ducts; the forward portions of the engines and between them a water tank, and the main undercarriage and engine accessories bay, which were located in the lower quarters of the fuselage and flanked the centrally-positioned weapons bay that ran the whole length of the section. The water from its tank was sprayed into the engines' combustion chambers to restore thrust for operations in hot conditions. Each leg of the forward-retracting main undercarriage carried a pair of tandem-staggered large-diameter low-pressure wheels mounted on a bogie beam which was rotated to align with the leg before retraction. The large main doors covering the stowed undercarriage were designed to close again after the mainwheels had been lowered. This double cycle arrangement, which was later adopted for the nosewheel doors also, was intended to reduce the loss of lift and increase in drag that would have resulted if the bays had been open during take-off and landing. The rear-fuselage was mainly occupied by No.3 and No.4 fuel tanks, the rear portions of the engines and the jetpipes: the tanks almost completely surrounded the power units. The spigots, about which the fin and tailplanes were rotated, were attached to a frame that also served as the rear bulkhead for tank No.4. The rear fuselage was later redefined to include the whole of the powerplant installation. Three airbrakes were carried on the rear fuselage, one on each upper shoulder and one centrally on the lower surface. The fuselage was completed by a detachable fairing which provided stowage for the brake parachute and formed a shroud for the jetpipes' ejector nozzles.

The thin delta wing was of multi-web construction with integrally stiffened skin panels, the primary structure containing two integral fuel tanks. There were few ribs and these were positioned where required to diffuse loads from the trailing-edge flap hinges and external stores and wing/fuselage attachment points. The outer two-thirds of the leading-edge was extended forwards of the main wing, the inner half of the extension being made into a plain flap creating a saw-tooth at its inboard end and a notch as its junction with the fixed outer portion. The flap was intended to assist in providing stability at low speeds when the main flaps were deployed more than 15°. The innermost part of the leading-edge was fixed and incorporated a high-frequency radio notch aerial at each apex. The whole free length of the trailing-edge was occupied by plain tapered blown flaps.

The low-aspect ratio delta tailplane was low set and provided combined aileron and elevator functions. Plain trailing-edge flaps were fitted to the tailplanes and were geared to their movement and to blown-flap deployment to increase tailplane effectiveness and to reduce their range of travel at low speeds. The flaps were automatically locked in the neutral

position at high speed. The structure of the tailplane and the fin was similar to that of the wing. Even though the aircraft was shown with an all-moving fin, no final decision had been made in favour of this rather than a conventional fin and rudder. Investigations were still proceeding but soon resulted in the adoption of the former type, although it proved particularly difficult to optimise to meet the required aerodynamic, aeroelastic, and structural criteria.

A study of TSR.2 during a flight from Warton. (*British Aerospace*)

The aircraft was powered by two Bristol-Siddeley Olympus B.O1.22R pure-jet engines. The engine was derived directly from the Olympus B.O1.15R by the addition of a zero-stage to the low-pressure compressor and had a fully-variable reheat system, the simple convergent exhaust nozzle fitted progressively opening with increasing reheat temperature. The large amount of thrust available was considered essential to ensure good take-off characteristics and in fact in some circumstances gave the TSR.2 a better rate of climb than the Lightning. Each engine was controlled automatically by an electrical system using a conventional throttle box. The engine intakes preferred at that time were of the variable double-wedge type, located ahead of the wing. Alternative forms of intake were also being evaluated from aerodynamic and engineering viewpoints, among them a half-cone type mounted on a variable-wedge hinged about the cone apex.

The aircraft's navigational attack system used the forward and sideways-looking radars, the doppler radar and the inertial navigator. The primary function of the forward-looking radar, then under development by Ferranti, was terrain following but it was also used for homing and for weapon guidance and ranging. The doppler measured ground speed and drift angle to a very high degree of accuracy throughout the aircraft's flight envelope and supplied inputs to a display in the navigator's cockpit and to the navigation and bombing computer. Directional information was provided by a doppler-inertial mixed dead-reckoning system. Position readings from the two units were fed into a central computer, which checked them against a predetermined course. Any deviations from the flight path were calculated by the computer and the corrections obtained from it fed to the autopilot which returned the aircraft to its original course. Navigational errors accrued over long distances were periodically

checked at predetermined points on the flight path by the sideways-looking radar, which provided the navigator with a picture of the local terrain thereby enabling him to pinpoint his position exactly and to feed the aircraft's co-ordinates directly to the navigation computer. The sideways-looking radar could provide information in blind conditions at high and low altitudes. In addition, a photographic record, which was used for reconnaissance purposes and the correction of maps, could be obtained from the radar display. The two aerials of this radar were located on either side of the aircraft below the cockpit floor.

The TSR.2 was capable of delivering with a high degree of accuracy various combinations of weapons carried internally or on under-wing pylons. Its primary armament included nuclear or conventional high-explosive bombs, 2- or 3- in. air-to-surface rockets, or air-to-surface guided weapons. In addition, under-wing fuel tanks could be carried and an extra tank supplanting the armament could be fitted in the weapons-bay for long-range ferry flights. The large quantity of fuel carried in this case later led to the aircraft being considered in a tanker role. Strike/reconnaissance sorties were performed using the aircraft's basic equipment comprising the sideways-looking radar and three cameras permanently installed in the nose fuselage. More specialised reconnaissance missions used a pack containing cameras, Linescan, and radar, fitted within the weapons-bay, the information obtained being either recorded or transmitted directly back to base for analysis.

The way in which production and flight testing was to be shared between the two companies was initially agreed in March 1959. These arrangements had not altered at the time the brochure was submitted in July and still called for all aspects of the work to be shared equally, although no final agreement had been reached on this. Vickers was to design and produce the wings, front fuselage and undercarriage, and be responsible for the equipment. English Electric was to design and produce the remainder of the airframe and have responsibility for the powerplant installation and some of the associated systems. Both companies reserved the right to manufacture their parts of the aircraft by their own methods. Flight testing was to be shared equally. All planning for production was based on the assumption that notification to proceed with the aircraft and a development contract would be received by September 1959 to enable the companies to meet the required in-service date of 1965–66. On this basis the first flight of TSR.2 was scheduled for January 1963, forty-four months after receipt of the development contract. To meet this programme, the companies had to begin detail design in April 1960, start manufacture in the following July and complete final assembly in October 1962. Initially ten, later nine, flying development, one structural test and one fatigue test aircraft were required to obtain the full certificate of airworthiness for the type and to achieve its release into service by January 1966. Agreement on work sharing arrangements was reached in the month following the submission of the July brochure. Vickers then became responsible for the nose and centre fuselages and the avionics and systems incorporated in the forward portion. This section of the aircraft was to be built and assembled at Weybridge. English Electric was to design and produce the wing, rear fuselage and empennage, all fully equipped, and be responsible for the powerplant installation. Manufacture and assembly of the various major

components was shared among English Electric's factories in Lancashire: Strand Road assembling the rear fuselage from parts made there and at Accrington; Samlesbury assembling the wing from items made at all three factories and Accrington producing the entire fin and tailplanes, which last was designed by Vickers. The rearmost fairing was finally to be made by Bristol-Siddeley and the Vickers-designed undercarriage was produced by Electro-Hydraulics Ltd.

In addition, responsibility for design integrity was also shared, Vickers taking the cockpits, overall structure, avionics and electrical and air systems and English Electric taking aerodynamics and the hydraulic and fuel systems. Assembly and equipping of the first two development aircraft was to take place at Weybridge and from there the aircraft were to be taken to nearby Wisley aerodrome for the aircrafts' first flights. However, a decision taken during 1963, led to the A & AEE, Boscombe Down, being selected for final assembly and the initial flights, due to the restricted runway length at Wisley. Final assembly of the remainder of the development batch was to take place at Weybridge and of the pre-production aircraft at Samlesbury. Subsequently, in December 1964, it was announced that the final assembly of production aircraft would also be done at Samlesbury and all flight testing would be conducted from Warton.

In October, 1959, the English Electric project team returned to Warton from Weybridge. The phase which followed the completion of the project definition study was concerned with producing detailed schemes of the structure and systems based on the work done during the earlier phase. This period was protracted pending the receipt of a full development contract for the first nine aircraft, which was eventually received in October 1960. The lateness of this contract and financial cover for materials was to be the start of a number of delays which accumulated and resulted in TSR.2's first flight taking place 18 months behind schedule. Meanwhile the formation of the British Aircraft Corporation was announced on 1 January, 1960.

The most apparent changes made to the layout of the aircraft during 1960 were the adoption of variable half-cone intakes and distinctive wingtips with pronounced anhedral, and the abandonment of leading-edge high-lift and airflow control devices. The last two changes resulted from wind-tunnel tests started in April 1959 to measure the effects of various modifications to the wing. Less apparent changes to the layout were small increases in the lengths of the front fuselage and rearmost fairing, refinement of the rear fuselage lines and alterations to the tailplane and fin profiles, an all-moving fin having been finally chosen. Other changes included a nose undercarriage leg designed to extend during the take-off run to relieve the lift forces on the tailplanes and to reduce the speed at which the nosewheel begins to lift and thus to shorten the take-off run (during taxi-ing trials this feature was found to be unnecessary, take-off performance being better then predicted); four airbrakes, instead of three, were fitted to each of the upper and lower shoulders of the fuselage.

The development contract covering the construction of nine flying and two ground test aircraft was signed on 6 October, 1960. This event was followed in November by Vickers formally placing a sub-contract with English Electric for the latter's work and responsibilities. These aircraft

and those to follow were to be built to specification RB 192D, which was the final form of OR 343 issued in the preceding August. The next contract to be signed, on 28 June, 1963, was for 11 pre-production aircraft and was followed by another on 20 March, 1964, for the material for 30 production TSR.2s. Although both companies had put considerable effort into refining the aircraft from a number of aspects, the design phase still required the time originally allocated and manufacture began in July 1962, twenty months after receipt of the development contract as planned but one year later than expected. The first major sub-assembly completed by English Electric was the rear fuselage which was sent by road to Weybridge arriving there on 7 March, 1963. This was followed by the first prototype's wing, tailplanes and fin in March and April. Rear fuselages for the second prototype and structural test aircraft were completed within the next six months, the latter being sent directly to RAE, Farnborough, where the tests were to be made.

Meanwhile, a number of support programmes had been initiated to obtain aerodynamic data and to test items of equipment required for TSR.2. Possibly the largest of these was that related to the Olympus engines, which involved Bristol-Siddeley's own testing facilities at Patchway, adjacent to Filton, the National Gas Turbine Establishment at Pyestock and the Vulcan flying test-bed XA894. The programme, however, did not proceed smoothly being dogged by a number of engine problems, one of which resulted in the destruction of the Vulcan in December 1962. The engine problems were mainly associated with resonance of the low-pressure turbine shaft excited by the cooling airflow to the shaft's bearings. The cause of the problem was not identified until August 1964. By then TSR.2 was about to begin taxi-ing trials at Boscombe Down and there was insufficient time to fit modified engines without further delaying the imminent first flight. Therefore, the decision was made to limit the use of reheat to about two minutes during take-off and climb out, and then to reduce power to lessen the risk of resonance.

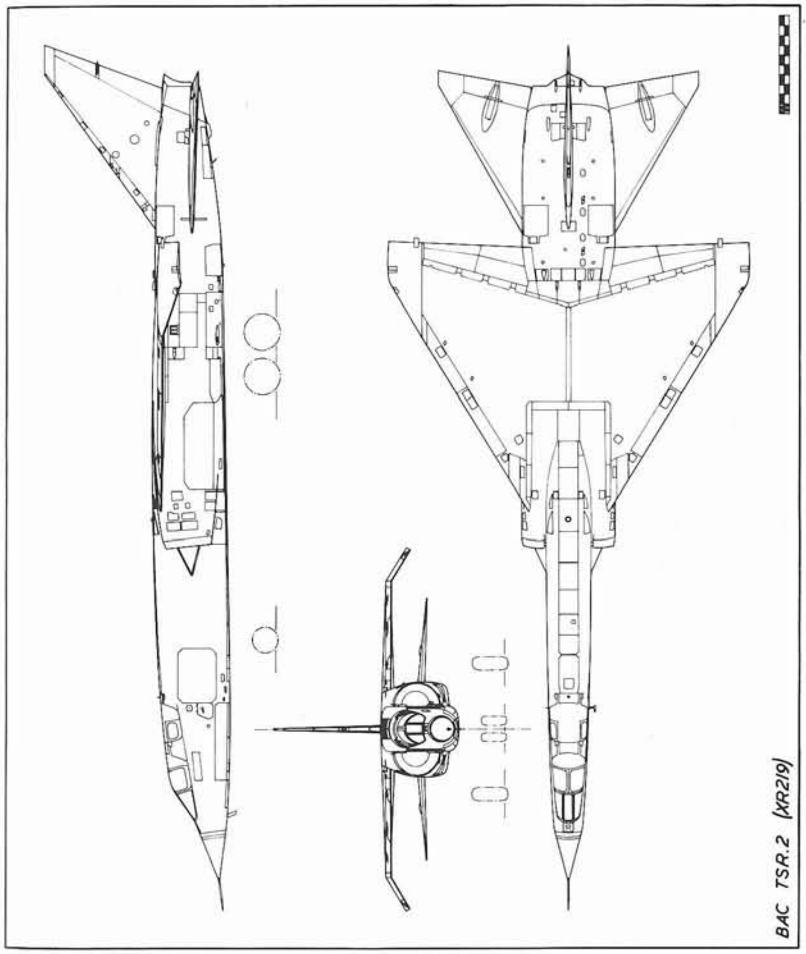
TSR.2 was revealed to the public for the first time on 28 October, 1963, receiving extensive and generally favourable coverage by the national news media. Unfortunately, its début took place amid a storm of controversy over Australia's decision to purchase two squadrons of the General Dynamics F-111 from the USA instead of the TSR.2, the sale of which to the Australians was then being negotiated by the British Government. The F-111 was still being designed at the time but its first flight was to take place only three months after that of TSR.2. One of the factors which was reported as influencing the Australians' decision was the reputedly lower cost of TSR.2's rival. This was to trigger speculation about the cost of developing the British aircraft and because of the figures quoted its operational effectiveness and even its necessity were questioned and hotly debated. From then TSR.2 was seldom out of the news and became the subject of unprecedented political attention, which increased when the Labour Party was elected to Government in October 1964.

The first prototype TSR.2 arrived at Boscombe Down on 6 March, 1964, where it was then finally assembled and equipped. There was no official roll-out ceremony and the aircraft's removal from the hangar on its own undercarriage to an adjacent apron on 6 May was treated as a matter of course and done so that the engine starter system could be tested. Engine

The second prototype TSR.2 undergoing fuel checks at Boscombe Down in February 1965. *(British Aerospace)*

testing began on 8 May and was conducted continually during the summer, being interrupted only when the aircraft was returned to the hangar to be brought up to flight standard, for modifications resulting from the testing, and for systems checks. The first taxi runs were made on 2 September by Roland Beamont, who had been appointed BAC's deputy chief test pilot, and Donald Bowen, chief test navigator, TSR.2. Afterwards all taxi-ing trials before the first flight were made by Beamont unaccompanied by Bowen. The principal object of the tests was to evaluate the performance and control of the aircraft progressively under simulated take-off and landing conditions. This was successfully achieved but not without encountering some minor development problems which led to delays. The main causes of these were hydraulic and fuel systems leaks and failure of the parachute to deploy on two occasions when the aircraft was taxi-ing at 140 knots, which resulted in the brakes seizing through overheating in bringing the aircraft to rest. No serious defects were found with the engines and they generally performed well throughout the trials. The last taxi run before the first flight was made on 22 September and was completely successful. The next few days were spent preparing the aircraft for flight and undertaking final checks.

The first flight of TSR.2 XR219 was made on Sunday, 27 September, 1964, by Beamont and Bowen. The preparations had begun at 8.45 am with engine runs lasting 45 minutes. These were followed at noon by a final taxi test to check controls and operation of the parachute and brakes, the crew having sat in their cockpits all morning preparing for the test and waiting for the ground mist to disperse before starting it. XR219 took off at 3.28 pm in clear sunny weather, escorted by Lightning T.4 XM968 flown by Jimmy Dell, and Canberra B.2 WD937 piloted by John Carrodus, and was airborne for 13 min 50 sec. The predominant factor determining the performance of the TSR.2 during its first flight was safety, it being previously decided to restrict the aircraft's take-off weight so that flight could continue and a controlled approach and landing could be made in



BAC TSR.2 (XR219).

the event of an engine failure without exceeding the imposed engine power limitations. Consequently, it was also decided to fit only that equipment essential for a first flight at low subsonic speeds so that the flight could be made as soon as practicable. TSR.2, therefore, flew with no automatic flight control system fitted, no automatic fuel balancing, with fixed intake-cones and auxiliary air-intake doors and with undercarriage extended, although the last could be retracted in an emergency. Beamont later recorded his comments on the first flight in an official report, the summary of which stated: 'In general the performance, stability and response to control conformed closely to the briefed values and especially to the simulator studies. Virtually all scheduled test points were achieved in this flight and this, coupled with the high standard of systems serviceability and the adequate level of un-autostabilized control and stability in this high drag, low speed configuration reflects a very high standard of design, preparation and inspection.

'In this first flight configuration and under the conditions tested, this aircraft could be flown safely by any moderately experienced pilot qualified on Lightning or similar aircraft, and the flight development programme can therefore be said to be off to a very good start.'

Afterwards, XR219 was laid up to change the engines and incorporate a number of alterations which included modifications to the few items Beamont had criticised in his report. Testing of the new engines started on 6 November but was interrupted by the need to remove them to remedy minor defects in other systems, by engine vibration trouble which necessitated replacing one of the engines, by malfunctioning of the auxiliary air-intake doors and by the need to check modifications to the starting system. The aircraft was again ready for flight on 23 December but the weather prevented this and a taxi test only was made. The second flight was made on 31 December, again by Beamont and Bowen, and lasted 13 minutes but its scope was restricted because of a recurrence of vibration in one of the engines, which had led Beamont to throttle it back to run at idling speed during the flight. Nevertheless the test results obtained were to confirm the data previously collected and show that the aircraft's performance was the same as or better than predicted. The source of engine vibration on the second flight was eventually traced to a reheat fuel pump pressure oscillation and the problem was cured before the fourth flight by fitting pumps made to higher standards of quality control. However, one problem not resolved and then receiving urgent attention was undercarriage vibration, which was felt by the crew just after touch-down on both flights as a low frequency lateral oscillation of sufficient magnitude to affect control of the aircraft on the ground. In the next phase of testing it was found that the effects of this phenomenon could be reduced by landing the aircraft at slower rates of descent and this expedient was adopted as a temporary measure only to allow flight testing to progress. A complete solution to the problem was found but the TSR.2 was cancelled before the necessary modifications could be incorporated fully.

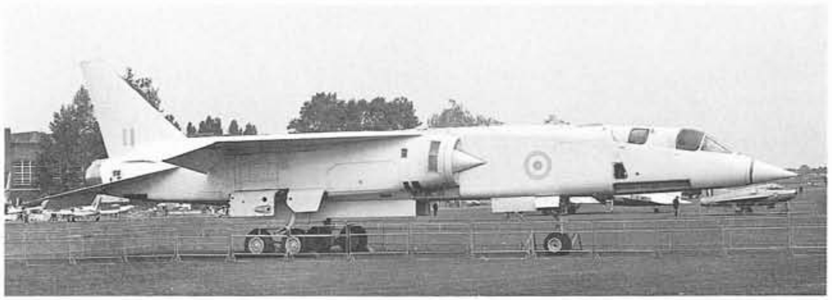
XR219 was flown for the third time on 2 January, 1965. Thereafter an unexpectedly good sortie rate of two flights a week was maintained, which served to demonstrate the high degree of reliability of the aircraft's systems despite new problems encountered with the undercarriage. The first

XR219 photographed on 22 February, 1965, en route from Boscombe Down to Warton airfield. *(British Aerospace)*

attempt to retract the undercarriage was made during the fifth flight, on 14 January, and resulted in the main bogies only rotating and then failing to derotate for the landing, which was made very gingerly. On some subsequent occasions only one of the main legs retracted completely. The undercarriage was finally retracted successfully during the tenth flight, on 6 February, after air-spring jacks were added to assist bogie rotation and other small modifications were made, whereupon the aircraft was taken immediately from its previous fastest speed of 270 knots to Mach 0.8 at 2,000 ft and to 511 knots in a fast run over the airfield at 70 ft. From then exploration of the flight envelope progressed rapidly and by 16 February a total of 5 hr 27 min flying time had been accumulated. In this period, the aircraft was for the first time also flown by Jimmy Dell and Don Knight and navigated by Peter Moneypenny, who were to be joined later at Warton by another navigator, Brian McCann.

On 22 February, it was flown to Warton, for the remainder of its flight testing, by Beamont and Moneypenny accompanied by Dell in the Lightning chase aircraft XM968. They left Boscombe Down at 1.15 pm and flew over Wales to Colwyn Bay where they started the first supersonic test run northwards over the Irish Sea, a maximum speed of Mach 1.12 at 29,500 ft being achieved and at which the TSR.2 performed perfectly. On arrival at Warton they gave a ten minute demonstration of the TSR.2 before assembled employees, the press and television cameras. The total flight time was 43 minutes.

In the meantime, the second prototype, XR220, had been delivered to Boscombe Down for final assembly and equipping, having arrived there on 9 September, 1964. Unfortunately, the fuselage was accidently damaged



The fourth TSR.2 prototype, XR222, on display during the Air Pageant held at the College of Aeronautics, Cranfield, on 8 and 9 September, 1973.

on arrival when the lorry carrying it jack-knifed as it entered the hangar and the fuselage toppled off the trailer. Consequently final assembly was delayed until the fuselage had been thoroughly inspected but the damage proved to be superficial. The time lost was regained and by 19 February, 1965, XR220 was being prepared for its first engine runs. These began five days later and were completed towards the end of March, when the aircraft was laid up for final checks before its first flight which was planned for the beginning of April.

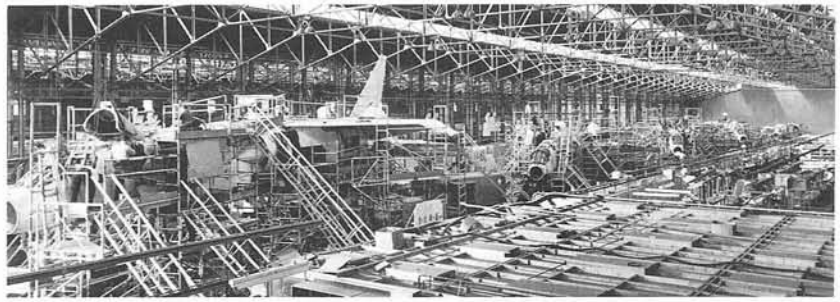
At the end of February, after completion of the sixteenth flight which brought the total time flown with XR219 to 8 hr 11 min, Beamont was able to report:

'At the end of this first stage of flight testing it can be said with certainty that TSR.2 is a sound and satisfactory flying machine with superior qualities of stability and control to the predicted or better than predicted values; and there is now good reason to suggest that a high success rate may be achieved in the remainder of the C.A. Release Programme.

'Without doubt the flying qualities of this aircraft are ideally suited to its design role, and it is potentially a highly successful design.'

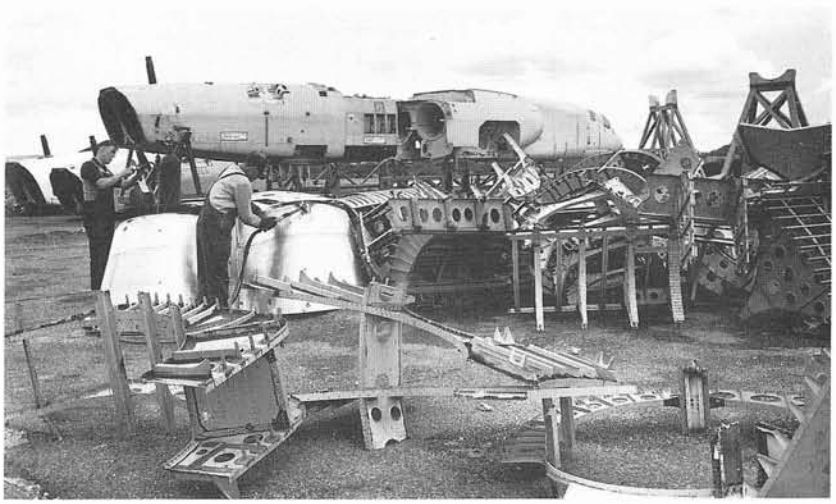
Thereafter XR219 made only eight more sorties, all of them flown during March, which added another 5 hr 3 min to its flight time. These flights expanded the low-altitude flight envelope up to Mach 0.9 at low level. They were also used to test modifications to the main undercarriage designed to eliminate the vibration present on landing. Consequently no high-altitude flights were made and the supersonic envelope was not investigated further. The aircraft's behaviour continued to prove satisfactory throughout the trials and no major problems associated with stability, control, or performance were found. Another flight planned for 2 April was aborted owing to a structural failure of the fin actuator. Before further flights could be made the TSR.2 project was cancelled.

The cancellation of TSR.2 was announced on 6 April during the Budget Day speech delivered by the Chancellor of the Exchequer. The project had been constantly under review since the General Election when the newly formed Labour Government stated its intention of re-examining previous defence policies. Speculation that TSR.2 would be cancelled as a consequence of this, increased after newspapers had, early in January, reported that an RAF team was in the USA to consider the purchase of the



The production line at Weybridge shortly before cancellation of TSR.2. (*British Aerospace*)

F-111 as a replacement for the TSR.2. The prospect of cancellation of not only TSR.2 but also other major aircraft projects not unnaturally raised serious doubts about the future of the whole of the British aircraft industry and led to high level discussions between it and the Government, culminating in a protest march in London on 14 January by 10,000 employees and their supporters. These events were followed by debates on the aircraft industry in Parliament, during which the Government stated that it had made no decision to cancel TSR.2 and that evaluation of the aircraft would continue while the cost of the project was discussed with BAC. The result of this review was expected in June but in the event was made known on Budget Day. Although BAC subsequently made proposals to use the completed TSR.2 prototypes for research, they were not accepted and the contract was officially terminated on 6 July, 1965. The total expenditure on the TSR.2 project up to that time, as stated in the Comptroller and Auditor General's Report—Civil Appropriation Accounts 1964–1965, was £125 million.



Components of TSR.2 being cut up for scrap at Samlesbury. (*British Aerospace*)

Date	January 1958		January 1958	July 1959	February 1965
Aircraft Type	English Electric P.17A		Vickers Type 571	VA-EE Type 571	BAC TSR.2
Crew	2		2	2	
Engines – No	2	2	2	2	
Manufacturer	Rolls-Royce	Bristol	Rolls-Royce	Bristol	
Type	RB.142	Olympus B.O1.14R	RB.142	Olympus B.O1.22R	
Rating – normal	13,300lbst	12,550lbst	13,300lbst	16,600lbst	
with reheat	22,700lbst	23,000lbst	22,700lbst	30,600lbst	
Dimensions – Span	35ft 0in		41ft 6in	37ft 1in	37ft 1.7in
Overall length	84ft 6in		77ft 0in	84ft 1in	89ft 0.5in
Height	22ft 0in		26ft 0in	24ft 8.5in	23ft 9in
Wing area	610sqft		430sqft	697sqft	702.9sqft
Weights – Empty	38,250lb		—	45,650lb	54,750lb
Normal take-off	66,000lb		81,225lb	85,100lb	102,200lb
Performance – Maximum speed at sea level	Mach 0.95		Mach 1.1	Mach 1.0 plus	
Maximum speed at altitude	Mach 2.0		Mach 2.3	Mach 2.0 plus	
Radius of action	1,000 naut miles		1,000 naut miles	1,000 naut miles	
Ferry range	3,300 naut miles		—	3,000 plus naut miles	

After cancellation, the first prototype was retained at Warton until 14 August, 1966, when it was sent by road to the Proof & Experimental Establishment at Shoeburyness, Essex. There it joined the almost completed airframes of XR221 and XR223 which had been taken from the production line at Weybridge in September 1965. Before this, XR219 was displayed during the Royal Aeronautical Society's centenary celebrations held at Warton on 11 June, 1966. It was reported that XR219 remained intact at Shoeburyness until January 1972, when it was noted that its tail had been blown off during weapons trials. XR220 remained at Boscombe Down until 20 June, 1967, when it was transferred to RAF Henlow and put into storage. In May 1975, it was taken to the museum at RAF Cosford. XR222 was sent to the College of Aeronautics, Cranfield, in October 1965, and at the Air Pageant held there on 8 and 9 September, 1973, became the first TSR.2 to be exhibited publicly. It was later moved to the Imperial War Museum at Duxford. The remaining airframes and components were scrapped.

Appendix A

Sub-contracted Production

During the 1914–18 war, the Coventry Ordnance Works, the Phœnix Dynamo Manufacturing Co, and Dick, Kerr & Co and, later, during and after the 1939–45 war, the English Electric Co, received a number of contracts for the manufacture of aircraft designed by other companies and organizations. The histories of these aircraft have been well documented and the authors therefore give in this appendix contractural details and an indication of Service use only where relevant to English Electric's history. The number ordered appears in parentheses after the type designation.

The Coventry Ordnance Works Ltd (1913–19)

B.E.2a and B.E.2b. (quantity not known). At least 13 delivered in 1914. Contract numbers not known. Serial numbers incomplete. Known serials: 235, 318, 347, 348, 368, 384, 468, 471, 474. RFC service: Nos.2, 4 and 6 Squadrons and CFS Upavon.

B.E.8. (2). Both delivered in 1914. Contract A.2567, dated 6 August, 1914. Serials 2131 and 2132.

B.E.8a. (21). Nineteen delivered from about May 1915. Contract A.2872, dated 11 August, 1914. Serials 2154–2174

R.E.7. (50). Order completed by the end of 1916. Contract A.2733. Serials 2185–2234. RFC service: No.35 (Reserve) Squadron. Transfers to RNAS: 2191, 2201.

B.E.12a. (50). All delivered; 41 in 1916 and remainder in 1917. Contract 87/A/401. Serials A562–A611. RFC service: Nos.1 and 14 Squadrons. Conversions: Five aircraft including A562 and A586 produced as B.E.12s under contract 87/A/215.

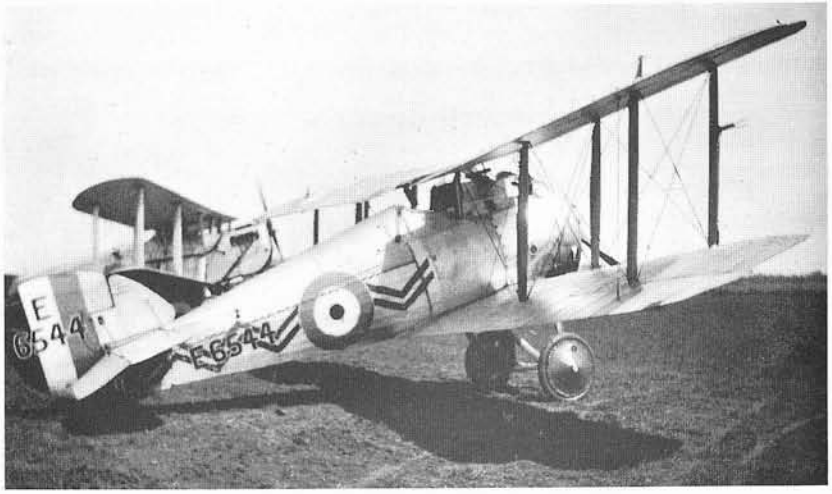
Central Flying School line-up at Upavon, July 1914. B.E.2a, 468, was built by the Coventry Ordnance Works. (*Flight International*)

COW-built B.E.8a 2154 at Farnborough, early in 1915. (*Leslie/Bruce Collection*)

COW-built R.E.7 2213. (*Leslie/Bruce Collection*)

COW-built B.E.12 A586. (*Leslie/Bruce Collection*)

COW-built R.E.8 B6644 presented to the Royal Flying Corps by A.G.L. of Stoke Poges. (*Leslie/Bruce Collection*)



COW-built Sopwith Snipe E6544 which served postwar with No.17 Squadron. (*via J. M. Bruce*)

R.E.8. (100). All cancelled. Contract 87/A/727, dated 16 June, 1917. Serials B4751–B4770. Contract AS.8871/17. Serials B4771–B4850. Serial numbers reallocated.

R.E.8. (120). All delivered by about November 1917. Contract 87/A/727, dated 20 September, 1916. Serials A4664–A4763, C5026–C5045. Cancelled contract for B4751–B4770 was replaced by C5026–C5045. RFC service: Nos.4A, 9 and 15 Squadrons. Presentation aircraft: A4711 *Malaya No.12*.

R.E.8. (180). All delivered by about the autumn of 1918. British requisition No. 108, dated 5 July, 1917. Contract AS.8871/17, dated 11 February, 1917. Serials B6631–B6730, C5046–C5125. Cancelled contract for B4771–B4850 was replaced by C5046–C5125. RFC/RAF service: Nos.9, 15 and 16 Squadrons. Presentation aircraft: B6644 *AGL, Stoke Poges*.

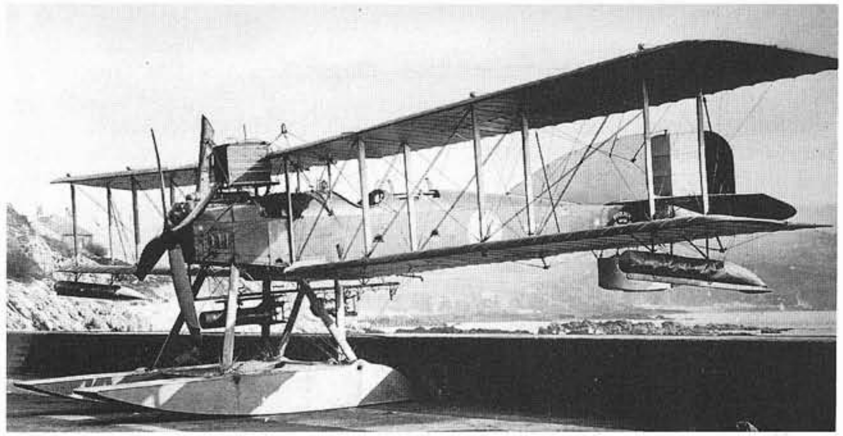
R.E.8. (150). All delivered by November 1918. Contract AS.27751, dated 9 January, 1918. Serials D6701–D6850. Australian Flying Corps service: No. 3 Squadron. RAF service: Nos. 9, 15 and 53 Squadrons.

Sopwith 7F.1 Snipe. (150). About 43 delivered; remainder believed cancelled. Contract 35A/437/C.304, originally dated 20 March, 1918, but recharged on 3 April, 1918. Serials E6537–E6686. RAF service: Nos.17, 23, 25, 43 and 112 Squadrons (postwar). Experimental use: E6611 on deck landing trials.

Sopwith 7F.1 Snipe. (150). All cancelled. Contract 35A/2042/2321, dated 25 July, 1918. Serials F9846–F9995.

The Phœnix Dynamo Manufacturing Co Ltd (1916–18)

Short Type 184. (12). All delivered between 12 January and 5 June, 1916. Contract CP.79176/15/X.37509, dated 28 July, 1915. Serials 8368–8379. C/ns not allotted. RNAS service: Dover, Felixstowe, Great Yarmouth, Killingholme and HMS *Manxman*.

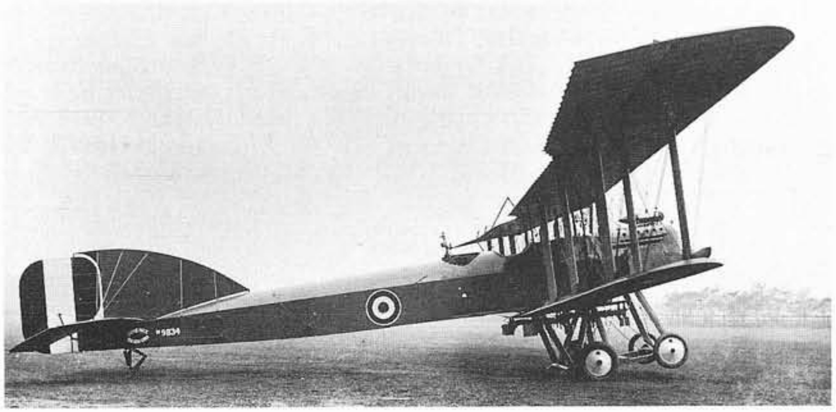


Phœnix-built Short Type 184 N1754 at Cattewater in 1918. (*Leslie/Bruce Collection*)

Short Type 184 spares. Contract CP.178209/W.392/2506a, dated 10 November, 1915. Spares comprised: ten sets of wings complete with ailerons, interplane struts, bracing wires and wingtip floats; twenty sets of tail units complete with rudder, elevator, and tail-float with water-rudder and tube; twenty sets of floats and chassis complete with struts, bracing wires and torpedo suspension.

Short Type 184 modification. Contract CP.118309/16/X.18814, dated 28 June, 1916. Modification consisted of fitting observation space in lower wings of ten aircraft. Observation space was fitted to 8376–8379 and to last six sets of spare wings.

Short Bomber. (10). Six delivered between 12 September and 2 November, 1916. Four cancelled. Contract cancelled 25 September, 1916. Contract CP.108243/16, dated March 1916. Serials 9831–9840. Cancelled aircraft: 9837–9840. Incomplete aircraft were delivered as spares to RNAS Central Supply Depot, White City, London. C/ns not allotted. RNAS



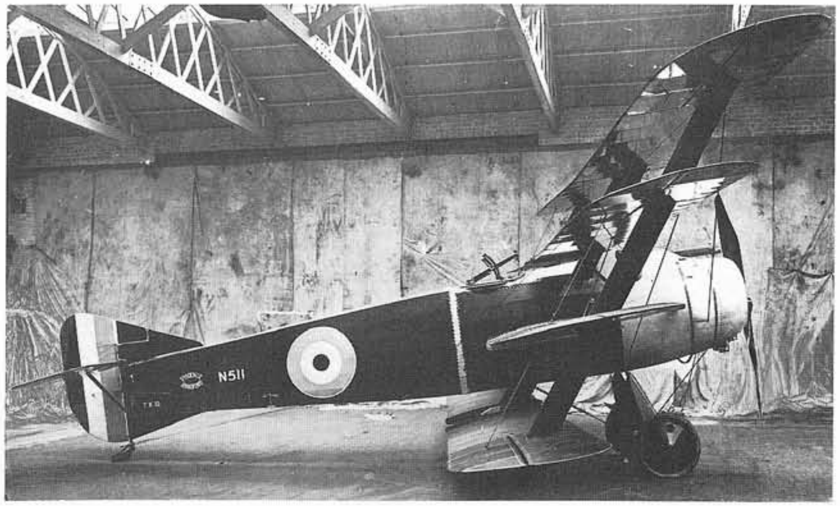
First Phœnix-built Short Bomber, 9834, was tested by Clifford Prodger on 3 August, 1916. (*via L. G. E. Brown*)

service: Eastchurch, Manston and Dunkirk. Transfers to RFC: 9832/A6300 and 9833/A3932.

Short Bomber spares. Contract CP.108243/16, dated March 1916. Spares comprised: two sets of wings complete with struts, bracing wires and all fittings, the first set to be delivered with 9835 and the second set with 9840; five undercarriages with wheels and tyres, the first and second sets to be delivered with 9835 and the remainder with 9840; two complete tail units to be delivered with 9835 and 9840 respectively. The spares were to be delivered to the RNAS Central Supply Depot, White City, but with the cancellation of the contract spares were sent with 9835 only.

Maurice Farman S.7 Longhorn. (20). All delivered between 22 December, 1916, and 13 March, 1917. Contract CP.120727/16. Serials

Phœnix-built Maurice Farman Longhorn N5333 photographed on Sunday, 7 January, 1917. It was dismantled the next day and despatched to RNAS Eastchurch on the following Tuesday. (*via L. G. E. Brown*)



Phœnix-built F.K.10 N511 just after completion at Bradford in April 1917. (*Leslie/Bruce Collection*)

N5330–N5349. C/ns not allotted. RNAS service: Chingford, Eastchurch and Killingholme.

Maurice Farman S.7 Longhorn. (10). All delivered between 14 March and 27 April, 1917. Contract CP.132300/16. Serials N5750–N5759. C/ns not allotted. RNAS service: Eastchurch and Killingholme.

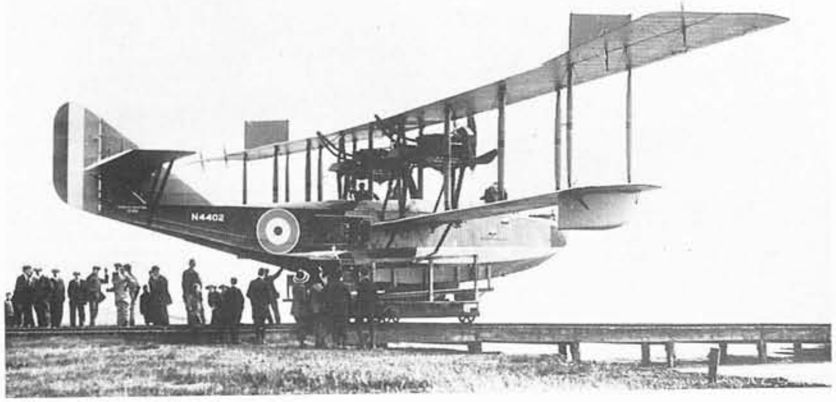
Armstrong Whitworth F.K.10 Quadruplane. (2). Both delivered about April 1917. Contract CP.135178/16. Serials N511 and N512. N511 completed as a fighter and N512 as a bomber. C/ns not allotted. RNAS service: Manston and Westgate (N511). N512 was delivered to store at Wormwood Scrubs, London.

Short Type 184 Dover. (30). All delivered between April and about November 1917. Contract AS.1247/17, dated March 1917. Serials N1630–N1659. C/ns 150-179 allotted in sequence. RNAS service: Alexandria, Grain, Houton, Killingholme, Lee-on-Solent, Malta, Rosyth and Suda Bay.

Short Type 184 Dover. (20). All delivered by about March 1918. Contract AS.10630. Serials N1740–N1759. C/ns 180-199 allotted in sequence. RNAS service: Alexandria, Cattewater, Dundee, Lee-on-Solent, Mudros, Portland, Rosyth, Strathbeg, Talikna, HMS *Ark Royal* and HMS *Nairana*.

Felixstowe F.3. (30). At least 27 delivered between February and 26 September, 1918. British requisition No.199. Contract AS.30620. Serials N4400–N4429. C/ns 200-229 not allotted in sequence. RNAS service: Catfirth, Cattewater, Dundee, Houton, Stenness and Tresco. Experimental use: N4400 and N4409. Stored aircraft: N4402, N4422–N4429. Exported aircraft: N4400/C-APON (Portugal).

Felixstowe F.3. (20). All delivered to store between September and December 1918. British requisition No.22. Contracts AS.30303 and



Phœnix-built Felixstowe F.3 N4402 (c/n 202) on the slipway at Brough. (*Leslie/Bruce Collection*)

AS.11426. Serials N4160–N4179. Contract shared between Phœnix and Handley Page, the former supplying hulls and the latter the flight structure (believed to be of an experimental form), with Phœnix undertaking final assembly. C/ns 230–249 not allotted in sequence. To civil register: N4177/G-EBDQ.

Felixstowe F.3 spares. A number of contracts (details unknown) were placed for spares, fittings and hulls, including: spares for N4400–N4429 and N4160–N4179; hull fittings for the Admiralty and wing fittings for F.3s built by the Malta Dockyard; four hulls used for N4180–N4183.

Felixstowe F.3/F.5. (50). Order not completed. None delivered before 31 December 1918. British requisition No. 348. Contract AS.4496/18. Serials N4180–N4229. Hulls ordered as spares were used for N4180–N4183, which were completed as F.3s. N4184–N4229 were ordered as F.5s.

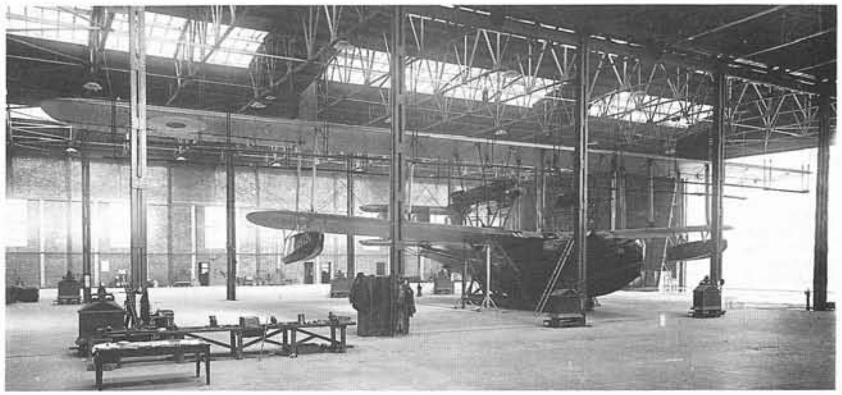
Felixstowe F.5. (50). All cancelled. British requisition No.622. Contract AS.26343. Serials N4780–N4829.

Felixstowe F.5 spares. Contract (details unknown) for 150 sets of hull fittings.

Fairey N.4 Atalanta II. (1). Aircraft not completed, hull only delivered to MAEE, Isle of Grain. Hull built by Gosport Aviation Co Ltd. British requisition No. 456. Contract 38A/374/C.359. Serial N118.

Dick, Kerr & Co Ltd (1917–19)

Felixstowe F.3. (50). At least 40 delivered between 14 March, 1918, and January 1919. British requisition No.72. Contract AS.13823. Serials N4230–N4279. C/ns S.1–S.50 not allotted in sequence. RNAS service: Catfirth, Cattewater, Dundee, Felixstowe, Houton, Killingholme, Stenness and Tresco. Experimental use: N4236 for navigation experiments. Stored



Dick, Kerr-assembled Fairey Atalanta I N119 inside the hangar at Lytham. There was only just enough room to assemble the aircraft between the roof stanchions and joists. A series of catwalks was suspended from the roof to enable the fitters to work on the upper wing. Condor engines were not available at that time and those fitted were mock-ups. (*The English Electric Co Ltd*)

aircraft: N4246, N4257, N4259, N4261–N4267, N4274, N4275, N4278, N4279.

Felixstowe F.3/F.5. (50). Order not completed and none of the aircraft were delivered in 1918. British requisition No. 347. Contract AS.4499. Serials N4100–N4149. N4100–N4117 ordered as F.3s, the remainder as F.5s. Completed aircraft were N4100–N4110, N4120, N4121.

Felixstowe F.5L. (50). All cancelled. British requisition No. 621. Contract AS.26344. Serials N4730–N4779.

Fairey N.4 Atalanta I. (1). Aircraft completed 1921. Hull built by May, Harden & May Ltd. Contract 38A/373/C.360, dated 13 May, 1919. Serial N119. Experimental use: MAEE Isle of Grain.

The English Electric Co Ltd (1938–52)

Handley Page Hampden I. (75). All completed between 19 March and 30 July, 1940. Contract B952962/38, dated 21 December, 1938 (effective from 6 August, 1938). Serials P2062–P2100, P2110–P2145. RAF service: Nos. 49, 50, 83, 106, 144 and 408 Squadrons. Conversions to TB.I: P2064, P2065, P2067, P2078, P2080, P2084, P2095, P2113, P2126 (last to USSR).

Handley Page Hampden I. (150). All completed between August and 4 December, 1940. Contract B994449/39, dated 21 May, 1939. Serials X2893–X2922, X2959–X3008, X3021–X3030, X3047–X3066, X3115–X3154. RAF service: Nos. 44, 49, 50, 61, 83, 106, 144, 408, 420 and 455 Squadrons. Conversion: X3115 to first prototype Hampden II. Conversion to TB.I: X2976, X3022, X3131 (all to USSR). Presentation aircraft: X3118 *Fiji III*.

Handley Page Hampden I. (125). All completed between 6 December, 1940, and 6 March, 1941. Contract B67577/40 (part 1), dated 20 December, 1939. Serials AD719–AD768, AD782–AD806, AD824–AD873. RAF service: Nos.44, 49, 50, 61, 83, 106, 144, 408, 420

Handley Page Hampden I AE394 nearing completion at Samlesbury in September 1941. At that time Halifax production was just starting, in the background is the third aircraft, V9978. *(British Aerospace)*

and 455 Squadrons. Conversion to TB.I: AD743 (to USSR). Presentation aircraft: AD719 *Istanbul.*

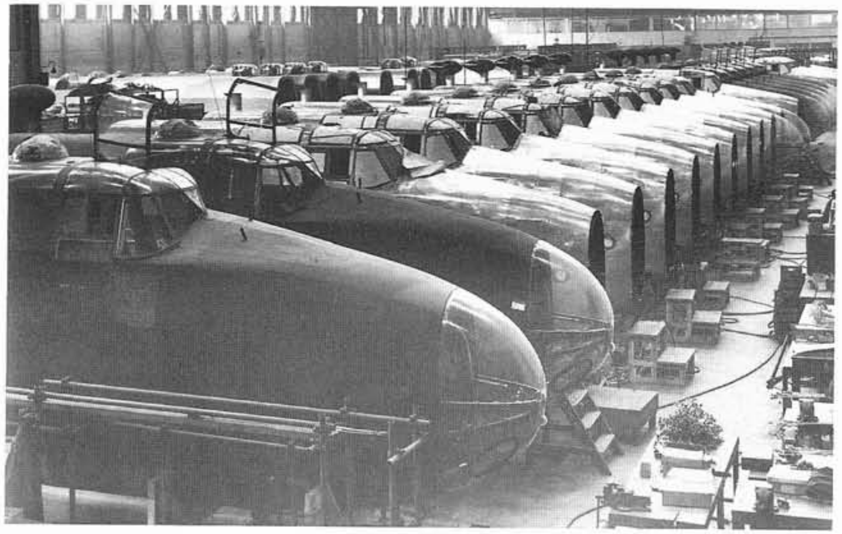
Handley Page Hampden I. (300). All completed between 6 March and 22 October, 1941. Contract B67577/40 (part 2), dated 6 July, 1940. Serials AD895–AD939, AD959–AD988, AE115–AE159, AE184–AE203, AE218–AE267, AE286–AE320, AE352–AE401, AE418–AE442. RAF service: Nos.44, 49, 50, 61, 83, 106, 144, 207, 408, 420, 455 Squadrons and No. 16 OTU. Conversions to TB.I: AD908, AD977, AE194, AE231, AE307, AE310, AE363 (all except AE363 to USSR).

Handley Page Hampden I. (250). One hundred and twenty completed between 23 October, 1941, and 7 March, 1942; remainder cancelled on 26 April, 1941. Contract B67577/40 (part 3), dated 23 July, 1940. Serials of aircraft built AT109–AT158, AT172–AT196, AT216–AT260. RAF service: Nos. 44, 49, 50, 83, 106, 144, 408, 420 and 455 Squadrons. Conversions to TB.I: AT109, AT114, AT117, AT125, AT135, AT139, AT145, AT150, AT184, AT193, AT195, AT232, AT241, AT243, AT244, AT251, AT254, AT256–AT259. Trials aircraft: AT139 as TB.I by Torpedo Development Unit, Gosport.

Handley Page Halifax II. (200). All completed between 20 September,

Handley Page Halifax DT585, a Mk II Series 1 aircraft, at Samlesbury in October 1942. *(British Aerospace)*

1941, and 29 August, 1942. Contract B982938/39 (part 1), dated 30 April, 1940. Serials V9976–V9994, W1002–W1021, W1035–W1067, W1090–W1117, W1141–W1190, W1211–W1253, W1270–W1276. RAF service: Nos. 10, 35, 51, 76, 77, 78, 102, 103, 158, 405, 419, 462 and 466 Squadrons. Trials aircraft: V9977 first aircraft to fly with H2S radar, first flight 27 March, 1942.



Final assembly stage of Halifax Mk III front fuselages at Strand Road, October 1943. Nearest the camera are the front fuselages for LW422 and LW423. *(British Aerospace)*

Handley Page Halifax II. (250). All completed between 20 August, 1942, and 26 February, 1943. Contract B982938/39 (part 2), dated 9 July, 1941. Serials DT481–DT526, DT539–DT588, DT612–DT649, DT665–DT705, DT720–DT752, DT767–DT808. RAF service: Nos. 10, 35, 51, 76, 77, 78, 102, 103, 158, 405, 408, 419, 462, 466 Squadrons and No.1666 HCU.

Handley Page Halifax II. (350) All completed between 12 February and 24 August, 1943. Contract ACFT/1808/C4C (part 1), dated 18 February, 1942. Serials JB781–JB806, JB834–JB875, JB892–JB931, JB956–JB974, JD105–JD128, JD143–JD180, JD198–JD218, JD244–JD278, JD296–JD333, JD361–JD386, JD405–JD421, JD453–JD476. RAF service: Nos. 10, 35, 51, 76, 77, 78, 102, 138, 158, 405, 408, 419, 428, 429 and 466 Squadrons.

Handley Page Halifax II and III. (360). All completed between 25 August, 1943, and 8 March, 1944. Contract ACFT/1808/C4C (part 2), dated 27 April, 1942. Serials Mk II: LW223–LW246, LW259–LW301, LW313–LW345. Serials Mk III: LW346–LW348, LW361–LW397, LW412–LW446, LW459–LW481, LW495–LW522, LW537–LW559, LW572–LW598, LW613–LW658, LW671–LW696, LW713–LW724. RAF service Mk II: Nos. 10, 35, 51, 77, 78, 102, 158, 419 and 429 Squadrons. RAF service Mk III: Nos. 10, 51, 76, 77, 78, 158, 190, 346, 347, 415, 420,

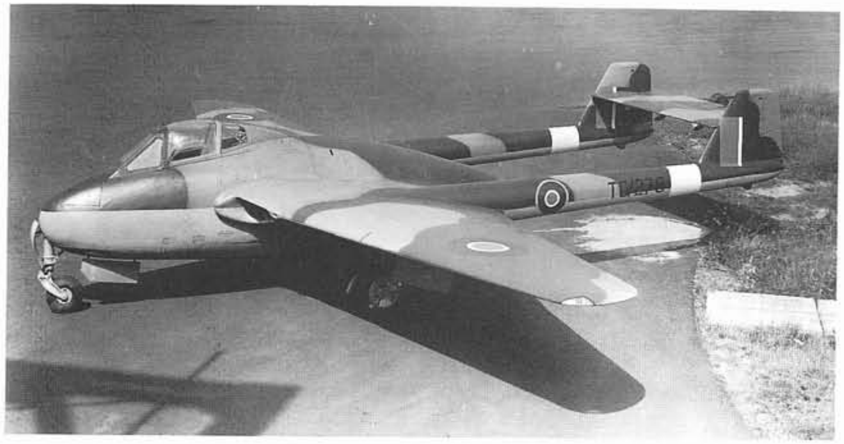
424, 425, 426, 427, 429, 431, 432, 433, 434, 462, 578, 640 Squadrons and No. 1659 HCU.

Handley Page Halifax III. (360). All completed between 9 March and 28 August, 1944. Contract ACFT/2553/C4C (part 1), dated 13 November, 1942. Serials MZ500–MZ544, MZ556–MZ604, MZ617–MZ660, MZ672–MZ717, MZ730–MZ775, MZ787–MZ831, MZ844–MZ883, MZ895–MZ939. RAF service: Nos. 10, 51, 76, 77, 78, 102, 158, 171, 192, 346, 408, 415, 420, 424, 425, 426, 427, 429, 431, 432, 433, 434, 462, 466, 578 and 640 Squadrons.

Handley Page Halifax III. (200). All completed between 30 August and 30 November, 1944. Contract ACFT/2553/C4C (part 2), dated 20 August, 1943. Serials NP930–NP976, NP988–NP999, NR113–NR156, NR169–NR211, NR225–NR258, NR271–NR290. RAF service: Nos. 10, 51, 76, 77, 78, 102, 158, 199, 346, 347, 408, 415, 420, 424, 425, 426, 427, 429, 431, 432, 433, 434, 462, 466, 578 and 640 Squadrons. To civil register: NR169/G-AGXA/VH-BDT.

Handley Page Halifax III, VI and VII. (400). All completed between 1 December, 1944, and 18 September, 1945. Contract ACFT/3362/C4C, dated 9 November, 1943. Serials Mk III: RG345–RG390, RG413–RG446. Serials Mk VII: RG447–RG458, RG472–RG479. Serials Mk VI: RG480–RG513, RG527–RG568, RG583–RG625, RG639–RG679, RG693–RG736, RG749–RG790, RG813–RG853, RG867–RG879. RAF service Mk III: Nos. 10, 51, 77, 158, 199, 426, 427, 462, 466, 517, 519, 578 and 640 Squadrons. RAF service Mk VI: Nos. 76, 77, 78, 102, 158, 202, 224, 346, 347, 466, 640 Squadrons and No. 1 Radio School. RAF service Mk VII: Nos. 408, 415, 426 and 432 Squadrons. Empire Air Navigation School: RG352 *Pollax*. Empire Radio School: RG815 *Mercury*. Conversions to Met. III: RG358, RG385. Conversions to GR.VI: RG778. To civil register: RG658/G-AKNG, RG695/G-AKJI, RG698/G-AKJJ, RG700/G-AKNH, RG712/G-AKNK, RG716/G-AKBI, RG717/G-AKNI, RG718/G-ALCY, RG720/G-AJTX, RG722/G-AJSZ, RG736/G-AKUT, RG756/G-AJTY, RG757/G-AJTZ, RG759/G-AKNJ, RG763/G-AKAP, RG774/G-ALCZ, RG779/G-AKLK, RG781/G-AKLJ, RG783/G-AKLI, RG784/G-AKAW, RG785/G-AJBE, RG790/G-AIBG, RG813/G-AKUU, RG822/G-ALDZ, RG824/G-AJUA, RG825/G-AJUB, RG826/G-ALEA, RG827/G-ALEB, RG847/G-ALEC, RG853/G-ALED, RG877/G-ALEE. To French Air Force: RG607 and RG867. To Pakistan Air Force: RG736, RG779, RG781, RG783–RG785.

Handley Page Halifax VI. (350). Twenty-five completed between 21 September and 30 November, 1945; remainder cancelled. Contract ACFT/3860/C4C, dated 22 May, 1944. Serials of aircraft built: ST794–ST818. Serials of aircraft cancelled: ST819–ST835, ST848–ST890, ST905–ST946, ST958–ST999, SV113–SV158, SV173–SV215, SV228–SV269, SV280–SV315, SV328–SV341. RAF service: No. 202 Squadron. Empire Air Navigation School: ST814 *Sirius*. To French Air Force postwar: ST795, ST797, ST799, ST800. Conversions to Met.VI: ST794, ST796, ST798, ST801–ST804, ST807, ST809–ST813, ST815, ST817, ST818. Conversions to transport: ST801, later to civil register as G-ALOM. Trials aircraft: ST808, trials with Servodyne powered elevator



The fifth de Havilland Vampire F.I, TG278, at Samlesbury in August 1945. (*British Aerospace*)

with English Electric in 1948.

Handley Page Halifax VI. (400). All cancelled. Contract dated 19 July, 1944. Serials probably in range TM384–TM943.

de Havilland Vampire F.I and F.3. (300). Two hundred completed. First of batch first flew 20 April, 1945; last of batch first flew 19 August, 1947. Contract 6/ACFT/5421/CB7(a), received June 1944. Aircraft ordered as follows: 120 aircraft, 13 June, 1944; 60 aircraft, 23 February, 1945; 120 aircraft, 7 May, 1945. Serials of aircraft built F.I: TG274–TG315, TG328–TG355, TG370–TG389, TG419–TG448, VF265–VF283, VF300–VF314. Serials of aircraft built F.3: VF315–VF348, VG692–VG703. RAF service F.I: Nos. 3, 20, 54, 72, 130, 247, 501, 605 Squadrons, No. 226 OCU and No. 203 AFS. RAF service F.3: Nos. 32, 72, 73, 247, 601, 604, 608 and 614 Squadrons. Empire Test Pilots School: TG345 and TG386. Trials aircraft: TG274–TG313, VF343, VF345, VG703. Conversion to F.20: VF315. To Fleet Air Arm: VF268 and VF269. To RAF Museum: TG349/7203M and VF332/7089M. To France: TG284, TG288, TG294, TG296, TG310, TG311, TG331–TG333, TG350, TG353–TG355, TG378, TG379, TG383, TG423, TG425, TG428, TG430, TG433, TG442. To Norway: VF320, VF323–VF326, VF328, VF330, VF331, VG692–VG696.

de Havilland Vampire F.II. (1). Completed in January 1947. Contract received early 1945. Serial TX807. Development trials with English Electric.

de Havilland Vampire F.I. (70). All completed. First of batch first flew April 1946; last of batch first flew 25 July, 1947. Delivered to Sweden. Sub-contract from de Havilland received early 1946. Serials 28001-28070. Subsequent service: About 20 to Dominican Air Force in 1952–53; a few to Austrian civil register, *eg* OE-VAC.

de Havilland Vampire F.I. (4). All completed between 6 July and 21 September, 1946. Delivered to Switzerland. Sub-contract from de Havilland received early 1946. Serials J-1001 to J-1004.

The third Vampire F.Mk II prototype, TX807, at Samlesbury in January 1947. This aircraft later had scoop air intakes added on the top of the fuselage. (*British Aerospace*)

de Havilland Vampire F.3. (85). All completed. First of batch first flew 3 June, 1947; last of batch first flew 2 February, 1948. Delivered to Canada. Contract 6/ACFT/218/CB7(a), dated 13 June, 1946. Serials 17001-17042, 17044-17086. Crashed aircraft: 17043 w/o 3 November, 1947, before delivery, replaced by 17086. RCAF service: Equipped five squadrons. To Rockcliffe Air Museum: 17074. To Mexican Air Force: No. 200 Escuadrone Aero; fifteen aircraft in service between 1961 and 1968; serials FAM-1 to FAM-15. To civil use in USA: About 40 aircraft to Fliteways Inc, West Bend, Wisconsin in 1958; of these, 26 transferred to US civil register for company use, including 17007/N6880D, 17012/N6882D, 17016/N6870D, 17017/N6873D, 17019/N6874D, 17020/N6865D, 17030/N6861D, 17039/N6871D, 17040/N6875D, 17044/N6866D, 17047/N6872D, 17065/N6862D, 17067/N6879D, 17071/N6883D, 17078/N6867D, 17085/N6868D.

de Havilland Vampire F.3. (64). All completed. First of batch first flew 20 August, 1947; last of batch first flew 18 March, 1948. Contract 6/ACFT/936/CB7(a), dated 13 December, 1946. Serials VT793–VT835, VT854–VT874. RAF service: Nos. 32, 54, 72, 73, 247, 601, 604, 608, 614 Squadrons and Odiham Station Flight. Conversions to F.20: VT795, VT801–VT805. Trials aircraft: VT861, high-altitude trials with English Electric in 1948; VT858, boundary layer control research by RAE and Cambridge University in 1953–55. Record aircraft: VT863, VT864, VT868, VT869, VT871 and VT873, all of No. 54 Squadron, were first jet aircraft to fly the Atlantic, July 1948. To RAF Museum: VT812/7200M. To Norway: VT832–VT835 as B-AB to B-AE.

de Havilland Vampire F.20. (18). All completed. First of batch first flew 23 June, 1948; last of batch first flew 26 October, 1948. Contract 6/ACFT/2677/CB7(a), received 1947. Serials VV136–VV153. Fleet Air Arm service: Nos. 700, 702 and 787 Squadrons.

de Havilland Vampire F.3 and FB.5. (46). All completed. First of batch first flew 22 March, 1948; last of batch first flew 17 August, 1948. Contract 6/ACFT/1053/CB7(a), dated 16 April, 1947. Serials F.3: VV187–VV213. Serials FB.5: VV214–VV232. RAF service F.3: Nos. 32, 72, 73, 604, 608 and 614 Squadrons. RAF service FB.5: Nos. 16, 54, 93, 234, 249 Squadrons and No. 5 FTS. Trials aircraft: VV190, flight test-bed

for DH Goblin 4 engine. To Norway: VV188/B-AF, VV212/B-AG, VV213/B-AH. To India: VV209–VV211.

de Havilland Vampire FB.5. (200). All completed. First of batch first flew 19 August, 1948; last of batch first flew 2 June, 1949. Contract 6/ACFT/1387/CB7(a), dated 27 April, 1947. Serials: VV443–VV490, VV525–VV569, VV600–VV640, VV655–VV700, VV717–VV736. RAF service: Nos. 3, 4, 6, 11, 14, 16, 26, 32, 54, 72, 73, 93, 94, 112, 118, 130, 145, 213, 247, 249, 266, 501, 502, 602, 603, 605, 607, 608, 612, 613 Squadrons, No. 8 FTS, Central Gunnery School and Central Fighter Establishment. Empire Test Pilots School: VV672. To prototype Mk 31: VV465, to Australia as A78-3. To prototype Mk 51: VV568, to France. To prototype Venom: VV612 and VV613. Trials aircraft: VV454, reheat trials with de Havilland. To France: VV718, VV720–VV723, VV725–VV736. To Lebanon: VV694.

de Havilland Vampire FB.5. (10). All completed. First of batch first flew 28 October, 1948; last of batch first flew 16 November, 1948. Probably ordered as replacements for aircraft exported. Serials VX461–VX464, VX471–VX476. RAF service: Nos. 11, 16, 26, 73, 249, 602 and 607 Squadrons.

de Havilland Vampire F.3. (3). All completed in May 1948. Delivered to India via de Havilland, Hatfield, October, 1948. Diverted from MoS contract. Serials VV209–VV211/HB544–HB546. Temporary civil registrations: VT-CXH to VT-CXJ.

de Havilland Vampire F.3. (8). All ex-RAF aircraft. Returned to Samlesbury from RAF August-October 1948. Delivered to de Havilland, Hatfield, October 1948. Delivered to Norway late 1948. Sub-contract from de Havilland, received 1948. First three aircraft handled by de Havilland, remaining five modified as necessary by English Electric. Serials VG692–VG696/B-AI, B-AK to B-AN. Royal Norwegian Air Force service: No. 336 Squadron.

de Havilland Vampire FB.5. (265). All completed. First of batch first flew 3 June, 1949; last of batch first flew 28 April, 1950. Contract 6/ACFT/2467/CB7(a), received 1948. Serials VX950–VX990, VZ105–VZ155, VZ161–VZ197, VZ206–VZ241, VZ251–VZ290, VZ300–VZ359. RAF service: Nos. 3, 4, 6, 14, 16, 32, 54, 72, 73, 93, 112, 118, 145, 213, 234, 247, 249, 266, 501, 502, 602, 603, 604, 605, 607, 608, 612, 613, 614 Squadrons, Nos. 5 and 8 FTS and Central Gunnery School. To Fleet Air Arm: VX973, VZ142, VZ143, VZ145, VZ146, VZ148. To Italy: VZ252–VZ256. To France: VX950–VX952, VX954–VX972, VZ120, VZ129, VZ130, VZ132–VZ142, VZ153, VZ154, VZ161–VZ169, VZ176, VZ191, VZ196, VZ197, VZ207–VZ209, VZ211, VZ215, VZ217–VZ223, VZ226, VZ257, VZ258, VZ270, VZ282, VZ284, VZ285.

de Havilland Vampire FB.5. (320). All completed. First of batch first flew 3 May, 1950; last of batch first flew 27 August, 1951. Contract 6/ACFT/2981/CB7(a), dated 29 September, 1948. Serials WA101–WA150, WA159–WA208, WA215–WA264, WA271–WA320, WA329–WA348, WA355–WA404, WA411–WA460. RAF service: Nos. 4, 11, 14, 26, 54, 60, 71, 72, 73, 93, 94, 98, 112, 118, 145, 185, 213, 234, 247, 249, 266, 501, 502, 602, 603, 605, 607, 608, 612, 613, 614 Squadrons, Nos. 5 and 7 FTS, No. 102 FRS, No. 202 AFS and Central Gunnery School.

de Havilland Vampire F.3. (8). All ex-RAF aircraft. Returned to

Samlesbury from RAF mid-1949. Delivered to de Havilland, Hatfield, July-September 1949. Delivered to Norway August-October 1949. Sub-contract from de Havilland, received early 1949. Serials VF323–VF326, VF328, VF320, VF330, VF331 / B-AO, B-AP, B-AR to B-AW. Royal Norwegian Air Force service: No. 336 Squadron.

de Havilland Vampire FB.5. (10). All completed. First of batch first flew 14 September, 1949; last of batch first flew 14 February, 1950. Delivered to South Africa. Sub-contract from de Havilland, received early 1949. Serials 201–210.

de Havilland Vampire FB.5. (20). All completed. First of batch first flew 27 August, 1951; last of batch first flew 15 October, 1951. Contract 6/ACFT/3974/CB7(a), dated 16 August, 1949. Serials WE830–WE849. RAF service: Nos. 98, 608 and 614 Squadrons.

de Havilland Vampire FB.5. (5). All completed. First of batch first flew 18 January, 1951; last of batch first flew 30 January, 1951. Probably ordered as replacements for aircraft exported. Serials WF578, WF579, WF584–WF586. RAF service: No. 93 Squadron.

de Havilland Vampire FB.5. (5). All completed between December 1949 and January 1950. Delivered to Italy via de Havilland, Hatfield, March 1950. Contract received 1950. Aircraft were diverted from a MoS contract. Serials VZ252–VZ256 / MM6000–MM6004.

de Havilland Vampire FB.5 and FB.9. (50). All completed. First of batch first flew 17 October, 1951; last of batch first flew 12 February, 1952. Contract 6/ACFT/5613/CB7(a), dated 25 August, 1950. Serials FB.5: WG840–WG847. Serials FB.9: WG848–WG851, WG865–WG892, WG922–WG931. RAF service FB.5: Nos. 5, 71 and 98 Squadrons. RAF service FB.9: Nos. 8, 28, 60, 73, 213 and 249 Squadrons.

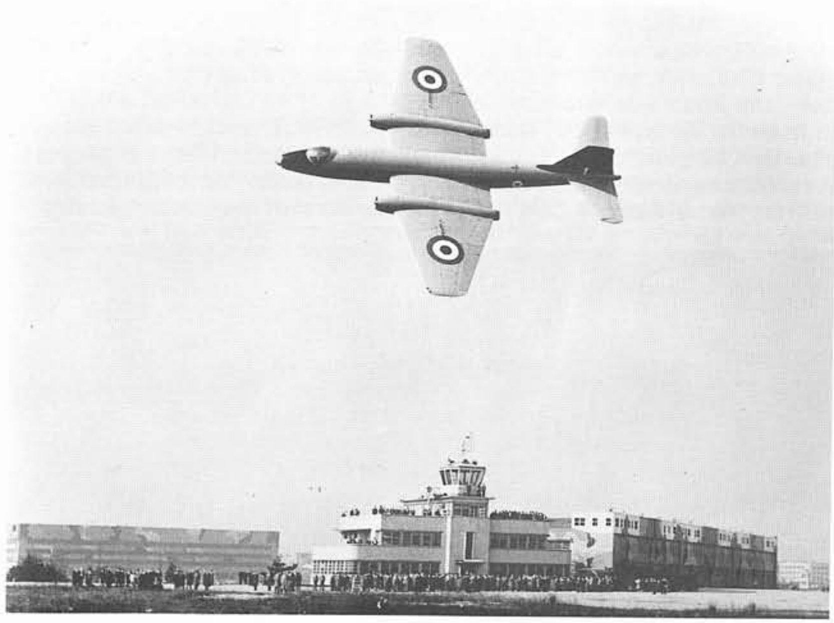
Appendix B

Licensed Production—Martin B-57

At the end of the 1939–45 war the USAF had three types of light bomber in service. Two of these, the North American B-25 Mitchell and the Martin B-26 Marauder, quickly became obsolete, and were withdrawn from first-line units by 1948. The third type, the Douglas A-26 Invader, remained in large-scale service until the middle 1950s. Before the end of the war design of the B-45 Tornado jet bomber had been started by North American, and the aircraft entered service late in 1948. The type proved to be of limited operational value, and production of a relatively small number was completed late in 1951. Experience in the Korean War showed that there was an urgent need for a light jet bomber of advanced design able to perform the night intruder role. The USAF therefore drew up a requirement for such an aircraft, which was to immediately replace the Invader, and also replace the Tornado eventually. An existing aircraft was to be chosen if possible due to the urgency of the requirement.

Five types were selected as contenders for the night intruder contract. One of these was the XB-51 close support aircraft which had been designed

and built by the Martin Company of Baltimore, and was of an unusual three-engined layout. The first flight was made in October 1949. About this time the Canberra first attracted American interest, as it appeared capable of performing the same role as the XB-51. During 1950, when the XB-51 was undergoing development flight test, American interest in the Canberra increased. In the summer several United States missions saw demonstrations of the Canberra in Britain, and as a result the Americans decided that it should be one of the contenders for the night intruder requirement. To enable further evaluation of the Canberra, the Americans asked that an aircraft be made available in the USA. The type had already made a favourable impression, with the result that in January 1951, the US Under Secretary for Air announced that either the Canberra or the XB-51 would be adopted by the USAF, the final choice depending on comparative trials. On 21 February, Canberra WD932 flew the Atlantic to compete in evaluation trials, and five days later was at Andrews Air Force Base, near Washington, to take part in an important demonstration for a party of senior Pentagon officials.



Soon after the highly successful demonstration of Canberra WD932 at Andrews AFB, Beamont displayed the aircraft to a crowd of 20,000 Martin employees and their families at Baltimore. (*British Aerospace*)

The demonstration at Andrews AFB was the last important stage in the selection process, and took the form of comparative handling trials of the types being considered. For comparison purposes three other types, besides the Canberra and XB-51, took part. These were the Douglas A-26 Invader, the North American B-45 Tornado and the North American AJ-1

Savage. The trials consisted of one flight by each of the five types, during which the aircraft had to perform a set sequence of manoeuvres within a time limit of 10 minutes. All four American types failed to complete the manoeuvres inside the time limit. However, after Beamont had taken the Canberra through the complete sequence, he found that 3½ minutes remained of the 10 minutes allowed. To emphasise further the Canberra's superiority, Beamont then performed two extra manoeuvres, after which he landed with a minute of the allowed time to spare. The verdict of the trials was in no doubt, and on 1 March the US Secretary for Air stated that the Canberra was considered to be the best light bomber available.

As American policy was that all equipment bought for the armed forces should be of American manufacture, Canberras ordered for the USAF would have to be built under licence in the USA. Accordingly, the Department of Defense announced on 6 March, 1951, that the Glenn L. Martin Company, of Baltimore, Maryland, was to manufacture the Canberra under licence from English Electric. The formal agreement for this was signed on 18 April, 1951. The choice of Martin to build the Canberra was logical once the decision had been made that the company's own XB-51 design should not enter production. The Martin identification of the Canberra was Model 272, and the USAF designation B-57. The name Canberra was not used for American-built aircraft, which were normally known as the Martin B-57.

After the Andrews AFB demonstration, WD932 was handed over to the Martin Company for flight-test work in preparation for the proposed American variants of the Canberra. WD932 was allotted the United States military serial number 51-17387, but the aircraft was never painted in

WD940, the second 'American' Canberra, seen over Baltimore soon after being painted in United States markings. The USAF serial number 117352 appears on the fin. (*Glenn L. Martin Co*)

American markings. In August 1951, Martin received a second Canberra, WD940, which was allocated the US serial number 51-17352. Some months after delivery it was painted with US military markings, thus becoming the first Canberra to carry these.

Martin received its first B-57 production order soon after the licence production agreement had been finalised. The contract called for 177 aircraft, comprising eight B-57As, sixty-seven RB-57As and one hundred and two B-57Bs. The B-57As were considered as being pre-production aircraft, the first true production variant being the RB-57A, which was intended for the tactical reconnaissance role. Both these versions were superficially similar to the Canberra, but the B-57B was distinguished by a redesigned front fuselage. Destined to be built in greater numbers than all other B-57 variants, the B-57B was to operate as a day and night light tactical bomber and intruder. Martin quickly began to prepare for large-scale B-57 manufacture, for further large orders were expected to follow.

The first step in putting the B-57 into production was for Martin very rapidly to re-engineer the basic Canberra to take account of the differences between British and American engineering specifications, standards and practices. G. M. Hobday of English Electric, with a small team of specialists, was assigned to Martin in this period, to provide assistance and advice. The aim was that the complete aircraft should be American made, so that this work had to be of a very detailed nature, down to such small parts as bolts and rivets. American suppliers had to be found for most of the items of equipment fitted to the aircraft, and provision had to be made for the equipment changes that were necessary to suit the aircraft for USAF operation. These alterations mainly concerned the radio, navigational, and bombing systems. In addition the bomb-bay was to be redesigned, and an American-built engine fitted. No major problems were encountered during re-engineering, and Martin largely attributed this fact to the basically simple design of the Canberra. By September 1951 a mock-up of the proposed B-57 production aircraft had been built, and during the month it was viewed by a USAF Board of Inspection. As a result of the Board's inspection the design standard for the initial production aircraft was agreed.

The redesigned bomb-bay of the B-57 was shorter than that of the Canberra, and was of the rotary type. Developed by Martin for its XB-51, the rotary bomb-bay was in the form of a revolving platform on which the bombs were carried. The underside formed part of the bottom surface of the fuselage, and the whole could be rotated through 180 degrees about its longitudinal axis, thus exposing the bombs without creating a large opening in the fuselage. Excessive turbulence was thereby avoided, enabling the aircraft to be flown more easily, and greater bombing accuracy achieved. The complete platform could be lowered from the aircraft for loading, and was refitted by means of three standard bomb hoists.

The engine selected to power the B-57 was the Wright J-65, which was the British Armstrong Siddeley Sapphire engine built under licence in the USA. The licensee was the Wright Aeronautical Division of the Curtiss-Wright Corporation, of Wood-Ridge, New Jersey. This company granted a sub-licence to the Buick Motor Division of General Motors, and the first J-65 engines produced were built by Buick at a large new factory at Flint,

Michigan. The J-65 was chosen to power several American-designed aircraft types, Wright having acquired its manufacturing licence in October 1950, some months before the agreement to build the Canberra in the USA. Wright made a number of changes to the basic Sapphire engine for American production, and the J65-W-1 engines installed in the B-57A produced a thrust of 7,220 lb. This thrust was 11 per cent greater than that of the Avon RA.3 in the Canberra, although the B-57 was to be heavier than the Canberra and therefore required an engine of greater thrust.

Output of the B-57 was to be at a higher rate than that of the Canberra. American practice was that high volume production programmes should be extensively sub-contracted, and the B-57 was to be no exception. During August 1951, Martin announced that a very large contract had been placed with Kaiser Metal Products Inc, of Bristol, Pennsylvania, for the manufacture of complete B-57 wings. In the same month a further announcement was made that the Hudson Motor Car Company of Detroit was to build rear fuselages, fins and tailplanes. The sub-contracted parts together totalled about 60 per cent by weight of the airframe. The remainder, comprising the front and centre fuselage sections, was to be built by Martin, which was also to undertake all final assembly and flight-test work. In addition to the two major sub-contractors, Martin also had some 3,000 other component suppliers. Two factories were situated on the Martin aerodrome at Middle River, near Baltimore, Maryland. Known as Plants 1 and 2, both had been built during the 1939–45 war for aircraft work. In 1951, Plant 1 was fully occupied by production of the Martin P5M Marlin flying-boat. Plant 2, however, had become a US Army depot after the end of the war. During 1951 the Army moved out, making Plant 2 available for B-57 manufacture and assembly. This large factory proved very suitable, and Martin recruited many thousands of new employees to work on the B-57 in Plant 2. Both of the major sub-contracting companies increased their labour forces by several thousands to fulfil their B-57 contracts, and Kaiser also built a large extension to its works. During late 1951 and 1952, Martin, Hudson, and Kaiser were engaged in tooling for B-57 manufacture and between them the companies eventually made about 25,000 tools, costing over $10 million.

The two Canberras supplied to Martin were used as test-beds for equipment intended for the B-57, and also to assess flying characteristics at weights representative of the B-57. Unfortunately this work was interrupted in December 1951 by the crash of WD932. Indeed, if the first indications that the accident was due to a design fault had proved correct, then the smooth progress of the whole project would have been jeopardised. However, the crash was found to have been caused by incorrect flying procedures. The trials work was continued by 51-17352 (formerly WD940), and among the features tested by this aircraft were the under-wing pylons and modified cockpit canopy of the B-57B.

By early 1952, manufacture by Martin and its sub-contractors had started and the volume of work in progress increased steadily during the year. The second production contract was placed with Martin in October 1952, and covered one hundred and ninety-one B-57B aircraft. This contract increased the number of aircraft on order to 368. However, not all were built, as the contract was later amended to call for only 158 aircraft, of which 120 were B-57Bs and thirty-eight B-57Cs, with the remaining

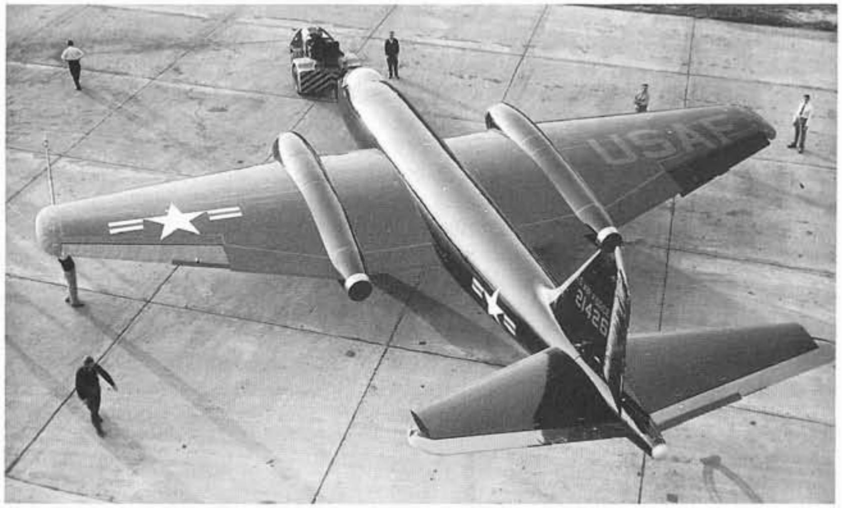
thirty-three B-57Bs being cancelled. A further amendment to the contract split the one hundred and twenty B-57Bs into one hundred B-57Bs and twenty B-57Ds.

The first B-57 to fly was 52-1418, the first of the eight B-57As. The flight was made on 20 July, 1953, from the aerodrome adjacent to Plant 2 where final assembly had been done. O.E. 'Pat' Tibbs, Martin's chief of flight test, was the pilot. Beamont later tested the aircraft, and found that it had handling qualities virtually identical to those of the British-built Canberra. Martin had completed its first aircraft just over two years after receiving the initial B-57 contract. This was a similar time to that taken by the British sub-contractors to produce their first Canberras. Although Martin had sub-contracted manufacture of a large proportion of the B-57 airframe, it had had to organize for a considerably greater production rate than the British sub-contractors, and in addition had completely re-engineered the design.

The first B-57A, 52-1418, during its first flight, on 20 July, 1953. *(Glenn L. Martin Co)*

The first B-57A, 52-1418, was used by Martin for engine and performance tests, and also for assessment of the cabin air-conditioning system. It was handed over to the USAF on 20 August, 1953, just one month after its first flight. At that time two further aircraft were complete, and both had flown by the end of September. The third aircraft, 52-1420, was used for stability and control work, structural integrity evaluation, and also for tests of the hydraulic and electrical systems. Further aircraft used for development flight-testing were 52-1421 and 52-1423, the fourth and sixth B-57As, which were used in armament and electrical equipment trials respectively. Other B-57As were used for Service evaluation. The Americanised aircraft was found to retain all the fine handling qualities of the Canberra, control responses being considered particularly good.

The B-57As were immediately followed off the production line by the



The first RB-57A, 52-1426, soon after completion. This was the first B-57 to be painted in the standard production scheme, which was gloss black overall, with red lettering and lining. (*Glenn L. Martin Co*)

first of the sixty-seven RB-57As on order. Intended for the tactical reconnaissance role, these aircraft were similar to the B-57A except for a camera bay aft of the bomb-bay. Production of the RB-57A built up so rapidly that deliveries were completed in the summer of 1954. Martin had therefore built 75 aircraft in the first year of production. By contrast English Electric completed only about 25 Canberras during the equivalent period, illustrating the different approaches of the companies to starting production. Whilst English Electric gradually phased in the Canberra alongside the Vampire, Martin's aim was to achieve large-scale production as quickly as possible. Martin retained the first and sixth RB-57As (52-1426 and 52-1431) for development trials.

From the beginning of the B-57 project, the primary role had always been that of tactical night intruder, and the RB-57A reconnaissance aircraft was therefore regarded as an interim production variant pending the introduction of the intruder. Designated B-57B, the night intruder first flew on 28 June, 1954, the first aircraft being numbered 52-1493. Designed as Weapon System WS307A, the B-57B differed from the basic B-57A in several respects. Most obvious was the redesigned front fuselage, in which the two crew members were seated in tandem under a new one-piece clamshell canopy, which provided improved visibility. In addition to the internal bomb load in the rotary bomb-bay, the B-57B had provision for a variety of stores to be carried on under-wing pylons, four of which were positioned under each outer wing panel. A fixed armament was also fitted; four machine-guns, or later two cannon, being installed in each wing leading-edge outboard of the engines. For improved speed control the B-57B had flap-type airbrakes on the lower flanks of the rear fuselage. These were complementary to and worked in conjunction with the finger-type

In October 1955 two B-57Bs, 52-1592 and 53-3862, visited Warton. The former aircraft is seen here parked alongside a Canberra B(I)8, allowing an interesting comparison to be made. (*British Aerospace*)

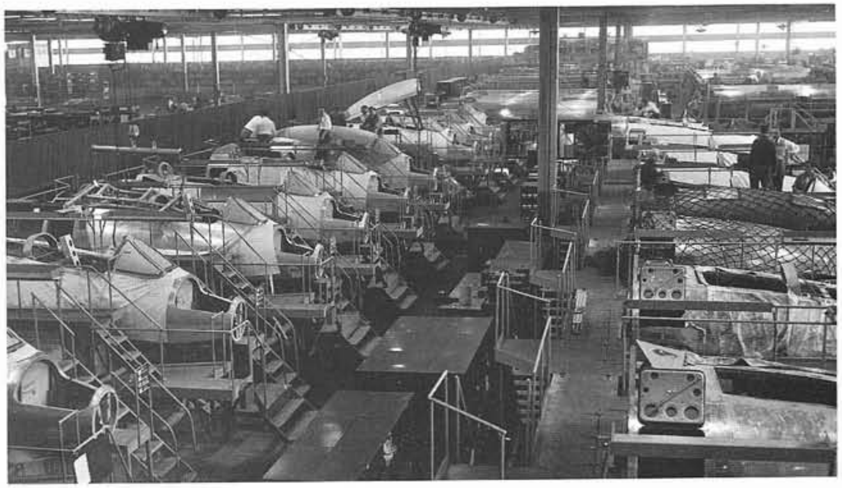
airbrakes on the wing, which had been retained from the original Canberra design. Various systems modifications were made in the B-57B, in particular to the fuel system due to the installation of guns in the wing.

The tactical night intruder role of the B-57B involved making low-level attacks on enemy road and rail communications, aerodromes, supply dumps, and other such installations, mainly by night. Hence the function of the B-57B was similar to that of the Canberra B(I)8 interdictor. However, the comparison between the B-57B and Canberra B(I)8 went beyond their roles, since each introduced a number of similar features: both aircraft had redesigned cockpit canopies for improved visibility, provision for under-wing stores, and carried guns. The first flight dates of the two types were less than one month apart, and both served with NATO tactical units in Germany.

A crew trainer was the next version of the B-57 to appear. Designated B-57C, this aircraft was identical to the B-57B apart from having provision for the fitting of dual controls. With these the aircraft was known as the TB-57C and was used for transition training, but it could be quickly converted for the intruder role. The first B-57C was 53-3825, which first flew on 30 December, 1954. The type was built in parallel with the B-57B, and each operational B-57B unit had a few B-57Cs for training.

Delivery of B-57s to the USAF started late in 1953, most of the first aircraft going to test establishments. The first operational unit to receive B-57s was 363 Tactical Reconnaissance Wing at Shaw Air Force Base, South Carolina. RB-57As replaced B-26 Invaders in this wing in mid-1954. In November 1954, RB-57As started to arrive in Germany, and during 1955 and 1956, the 10 TRW at Spangdahlem and the 66 TRW at Sembach received the type. The RB-57A replaced RB-26s and RF-80C Shooting Stars in these units. Deliveries of the B-57B started on 5 January, 1955, when the 345 Bomb Wing received its first aircraft. Based at Langley AFB, Virginia, the Wing was a Tactical Air Command Unit. The B-57Bs replaced B-26s, and re-equipment was complete by the end of the year.

Production of B-57Bs by Martin against the first and second contracts continued during 1955, and work started on two further versions. The first of these was the RB-57D reconnaissance aircraft, the second was the B-57E target tug. The RB-57Ds were ordered under the third contract received by Martin. This contract, finalised in late 1955, called for twenty RB-57Ds to



Production line for B-57B front fuselages at Plant 2, Middle River, Baltimore, 1954. (*Glenn L. Martin Co*)

be produced. The aircraft were transferred from the second contract, in which they had originally been ordered as B-57Ds. Martin's fourth and last production contract, for sixty-eight B-57Es, was signed in January 1956. The total number of aircraft to be built under all contracts was 403. Following the end of the Korean War in 1953, USAF orders for military aircraft were gradually reduced. This policy was responsible for the cancellation of aircraft from the second B-57 contract, and limited total production to a smaller number than had originally been envisaged. The curtailment of orders for the B-57 followed much the same pattern as the limiting of orders for the Canberra, which occurred at about the same time and for similar reasons.

The second Tactical Air Command wing to receive B-57Bs was the 461 Bomb Wing, based at Hill AFB, Utah. The next wing equipped was 38 BW at Laon, France. The fourth and last wing was 3 BW at Johnson AFB, Japan, receiving its aircraft early in 1956. During October 1955 two of the B-57Bs based at Laon visited Warton. These aircraft, 52-1592 and 53-3862, were there for two days, during which time their crews were taken on a tour of the Canberra assembly lines at Preston.

The first RB-57D to fly did so in November 1955, this variant being designed to perform specialised reconnaissance missions at altitudes of up to 70,000 feet. Extensive modifications were required for these missions, R. F. Creasey of English Electric acting as adviser to Martin and the USAF during the design work. This was a role which Creasey had held from the start of the B-57 project, and continued to fulfil for versions after the RB-57D. The fuselage and tail of the RB-57D were those of the B-57B, but to enable the aircraft to cruise at very high altitudes, the wing area was greatly increased and more powerful engines were fitted. The engine change, from the Wright J-65 to the Pratt & Whitney J-57-P-27, provided nearly 50 per cent more thrust. Four versions of the RB-57D were built, being known as

Group 'A' to 'D' aircraft. The six Group 'A' aircraft were intended for photographic-reconnaissance work, and were based at Yokota, Japan, from 1956. These aircraft had only the pilot, the mission not requiring a second crew member. There were seven Group 'B' aircraft, equipped for flight refuelling and electronic reconnaissance, which operated mainly in Europe. The balance of the 20 aircraft built was made up of six Group 'C' and one Group 'D', all being intended for electronic reconnaissance, and equipped for flight refuelling. The Group 'D' and Group 'B' aircraft both had only the pilot, but the Group 'C' aircraft had a second crew member. The electronic reconnaissance aircraft had special equipment installed in the fuselage, and radomes mounted on the nose and rear fuselage, increasing the length by up to 28 inches. Further radomes were fitted to the bottom of the fuselage. Some of the aircraft could carry further electronic equipment at the wingtips, the fairing for this equipment increasing the wing span by 18 inches.

The main USAF Command to operate the RB-57D was Strategic Air Command, which used the type in various parts of the world, including Europe and Japan. Some of the flights by SAC aircraft were concerned with intelligence gathering close to, and probably over, the Iron Curtain. The clandestine nature of some of the RB-57D's work resulted in very little information concerning the aircraft being published for several years. When it first appeared in 1956, the RB-57D was described as a high-altitude engine test-bed. Other commands operating RB-57Ds were Air Defense Command and the Military Air Transport Service. The former used the type in calibration work for the North American air defence radar network, whilst the latter, which was responsible for weather forecasting, employed the type for high-altitude air sampling.

The version of the Canberra most closely comparable with the RB-57D was the PR.9. Intended for reconnaissance at particularly high altitudes, the PR.9 was, however, only equipped for photography, there being no equivalent to the electronic reconnaissance versions of the RB-57D. Both aircraft had engines of greater thrust and wings of increased area, although the extra span of the PR.9 was far less than that of the RB-57D.

The final production version of the B-57 was the B-57E, which was the first type to be built for the USAF specifically as a target tug. The first aircraft was 55-4234, which flew in April 1956. Generally similar to the B-57B, the B-57E had provision for up to four banner-type targets to be carried in a fairing below the rear fuselage. Cable reels for these were mounted in the bomb-bay. However, the target-towing equipment could be readily removed, enabling the aircraft to be used as a tactical intruder. The B-57E could also be equipped to perform the tactical reconnaissance role as the RB-57E, and, as the TB-57E, could be used for transition training. B-57Es entered service with several Tow Target Squadrons, replacing Boeing B-29s. A target-tug version of the Canberra was produced some years later than the B-57E, although the Canberra TT.18s were not newly built aircraft, and carried quite a different type of target.

Martin completed production of the B-57 early in 1957, the last B-57E being delivered in March 1957. Output had reached 403 aircraft, 202 of which were B-57Bs, so that this type made up just over 50 per cent of the total. The RB-57A and B-57E each accounted for nearly 17 per cent of output, the B-57C nine per cent, the RB-57D five per cent, with the

remaining two per cent being B-57As. During the three and a half years of production, aircraft were completed at an average rate of nearly ten a month. By comparison, English Electric built Canberras for nine years, but the average rate was only about five and a half a month.

The North American F-100D Super Sabre supersonic fighter bomber appeared in January 1956. This event foreshadowed the eventual withdrawal of the B-57 from the USAF's Tactical Air Command, since the F-100D was to re-equip most of the Command's squadrons by 1960. The first TAC wing to relinquish its B-57s was the 363 TRW with RB-57As, which were withdrawn in 1957. Early the following year the 461 Bomb Wing with B-57Bs was deactivated, as was the 38 Bomb Wing in Europe. The only TAC B-57 wing then remaining was the 345 Bomb Wing with B-57Bs. This wing was not deactivated until June 1959. Although the B-57B went out of TAC service at this date, it was to remain in front-line service with the 3 Bomb Wing of the Pacific Air Force until 1964.

Some of the aircraft withdrawn from USAF service were made available for export. Nationalist China was the first recipient of such aircraft, one squadron of B-57Bs being delivered. In addition several RB-57Ds were supplied, these being used for reconnaissance flights over the mainland of China. Several years later one of these aircraft was reported to have been shot down whilst on one of these missions. In 1959, Pakistan became the second country to receive ex-USAF B-57s. A total of 25 aircraft was delivered, of which 22 were B-57Bs and three were B-57Cs. Some of the B-57Bs were modified as RB-57Bs to carry cameras. Re-equipment of two squadrons of No. 31 Bomber Wing of the Pakistan Air Force started in late 1959, the aircraft replaced being Handley Page Halifaxes. These had been supplied from Britain in 1949, several of the aircraft being of English Electric manufacture. One of the B-57Cs delivered to the Pakistan Air Force, 33846, was used as the personal aircraft of the Commander-in-Chief.

The Canberra was widely used in Britain for research and development purposes, and the B-57 proved to be equally suitable for such work in the United States. One of the first aircraft to be used was 21497, the fifth production B-57B, which was concerned in the development trials of the guidance system for the large IM-99 Bomarc ground-to-air missile. The nose section of a Bomarc, containing the guidance system, was fitted on to the nose of the B-57, increasing the overall length of the aircraft by 17 ft. Some years later two B-57Bs, 21535 and 21539, were modified as MSB-57Bs to test the guidance systems of TM-76 Mace tactical missiles. These aircraft were not, however, used for development, as the test work was of a routine nature. The modified aircraft were operated by a Mace-equipped tactical missile wing based in Europe. A number of B-57s were used to air launch guided missiles and rocket test vehicles. Probably the most numerous of all development B-57s were those used for testing radars, radio, and similar electronic equipment. Both military and civil organizations used B-57s for this type of work, one of the first being the Civil Aeronautics Administration. In 1958, the CAA was using two B-57As to test navigation aids at the cruising levels of the jet airliners then entering service. The FAA, successor to the CAA, also used B-57s, in particular for testing navigational facilities such as radio beacons. During the 1960s the National Aeronautics and Space Administration used a

number of B-57s, including NASA 218, which had originally been 52-1418, the first B-57A.

Although the B-57 was in first-line service with Tactical Air Command for only five years, the type was to serve with Air National Guard reserve units attached to TAC for nearly 15 years. Many of the aircraft withdrawn from TAC squadrons were transferred to the ANG, being used mainly for reconnaissance. Hence the five ANG Tactical Reconnaissance Squadrons which received B-57s were equipped mainly with RB-57As, although some B-57B and B-57C aircraft were also operated. These were modified to RB-57B and RB-57C standard. The last first-line USAF B-57 wing, 3 Bomb Wing in Japan, was deactivated in 1964. However two of the wing's three squadrons, the 8th and 13th Bomb Squadrons, remained in existence and later flew B-57s in Vietnam.

In 1963 the RB-57Ds were grounded after structural failures had occurred in the wings of a number of aircraft. However, a new variant of the B-57 was under development, which was more than capable of replacing the RB-57Ds. This variant, the RB-57F, was primarily designed for very-high-altitude air sampling and weather research and reporting. However, the aircraft was also obviously suitable for high-altitude military reconnaissance, and several were used for that purpose. Most of the RB-57Fs were derived from extensively rebuilt B-57Bs, although some RB-57A and RB-57D aircraft were also involved. The design and rebuilding was undertaken by the Fort Worth, Texas, division of the General Dynamics Corporation. The first aircraft, 63-13286, was flown in June 1963, and delivered to Edwards Air Force Base for evaluation. The RB-57F had an even better high-altitude capability than the RB-57D, being able to cruise at altitudes in the region of 80,000 ft to 90,000 ft.

In order to achieve such a remarkable high-altitude performance, the RB-57F was fitted with an even larger wing than that of the RB-57D. The span was 122 ft 5 in, very nearly twice that of the B-57B. This wing was of entirely new design, with three spars and aluminium honeycomb sandwich skin panels. The whole of the aircraft's fuel supply was carried in tanks which occupied most of the outer wing, endurance and range being reported as about 10 hours and over 4,000 miles respectively. The engine nacelles were similarly positioned to those of earlier B-57s, but were greatly enlarged to accommodate Pratt & Whitney TF33-P-11 turbofans. These each produced 18,000 lb st, and could be supplemented by two Pratt & Whitney J60-P-9 engines each rated at 3,300 lb st. These smaller engines were mounted on pylons under the outer wing, and could be detached if not required. With four engines the maximum thrust available was very nearly three times that provided by the engines of the B-57B, and all were specially adapted for ultra high-altitude operation.

The fuselage of the RB-57F was based on that of the B-57B, and retained the two-seat cockpit. However, considerable internal changes were made to carry electronic equipment, and a radome added to the nose of the aircraft increased the overall length by 40 inches. A redesigned and enlarged tail fin was fitted, although the tailplane was similar to that of the B-57B.

So extensive were the design changes made in the RB-57F that it was virtually a new aircraft, bearing relatively little relationship to the earlier B-57s. The connection with the Canberra was even more tenuous, but it

did exist, and the RB-57F was undoubtedly the ultimate development of the basic Canberra design. Indeed few aircraft types can have been so radically altered during development.

Initially two RB-57Fs were ordered, this quantity later being increased to 17, and finally to 21. The last four aircraft were the only ones to be derived from rebuilt RB-57Ds, and had a different equipment standard. They were intended specifically for reconnaissance work, rather than air sampling and weather flights. Owing to the very extensive modifications made during rebuilding, the RB-57Fs were treated as new aircraft, and allocated new serial numbers. Deliveries were made from 1964 to 1967, the type entering service in July 1964.

The first unit to receive the RB-57F was the 58 Weather Reconnaissance Squadron, based at Kirtland Air Force Base, New Mexico. The second weather squadron to receive the type was the 56 WRS, based at Yokota Air Base, Japan. Typically these squadrons had four or five RB-57Fs, as well as a few RB-57B, WB-57B or RB-57Cs. All weather squadrons were part of the Military Air Transport Service branch of the USAF. Other weather squadrons which operated various models of B-57 were the 54 WRS (Guam), 55 WRS (California and Alaska), and the 57 WRS (Australia). The main tasks of the WRSs concerned air sampling, atmospheric research and weather observation. Most RB-57Fs, serving with weather squadrons, were redesignated WB-57F. However, a few aircraft were used for military reconnaissance between 1965 and 1973, being based mainly in Germany and Japan for that work. The rapid progress in the development of reconnaissance satellites in the 1960s probably reduced the potential use of the RB-57F for military reconnaissance. However, there continued to be certain missions that could be better performed by aircraft. A wide variety of research and experimental programmes have employed the RB-57F, under the sponsorship of numerous official agencies and research establishments in the United States and abroad. Typical examples were specialised photography trials made to detect crop diseases, mineral resources and water pollution; calibration work connected with satellites;

WB-57F 63-13501 of 56 Weather Reconnaissance Squadron. Built as an RB-57F, the aircraft displays the main features of the type, notably the new wing, large main engine nacelles, underwing auxiliary engine pods, larger fin, and nose radome. (*MAP*)

investigation of high-altitude air currents and tropical storms; and the testing of new equipment.

The year 1965 saw B-57s engaged in two wars, both of which also involved Canberras. In September hostilities broke out between Pakistan and India. The Pakistan Air Force used B-57s and the Indian Air Force used Canberras, so that the uncommon situation arose of both sides using basically the same aircraft. During the 23 days of war there was intense activity by both air forces. The Pakistan Air Force stated that it had lost only two B-57s, and shortly after the end of the war twenty of its twenty-five B-57s took part in a flypast, to demonstrate that losses had not been heavy.

The other war in 1965 to involve B-57s was that in Vietnam. Early in the year this conflict, which had previously been of a guerilla nature, rapidly began to develop into a full-scale war, as a consequence of which USAF strength in Vietnam was greatly increased. Among the units involved were 8 and 13 Tactical Bomber Squadrons, both of which had earlier been part of 3 Bomb Wing based in Japan. These squadrons, equipped with B-57Bs, moved to Vietnam and were based at Bien Hoa AFB. They later moved to Phan Rang AFB, and served in Vietnam for about five years. The use of B-57Bs there resulted in a number of RB-57Bs being withdrawn from Air National Guard units in the USA, and converted back to B-57B bomber standard. In 1967 the B-57s at Phan Rang were joined by one squadron of Royal Australian Air Force Canberras. These aircraft, with the B-57s and four squadrons of F-100 Super Sabres, formed 35 TFW, and operated in the low-level ground support and night intruder roles. A few RB-57Es were used for photographic-reconnaissance work over Vietnam by 460 Tactical Reconnaissance Wing. Based at Tan Son Nhut, Saïgon, this wing used several other types, including RF-4Cs, RF-101s and RC-47s.

Martin received a contract in 1965 to refurbish and modernise nine of the RB-57Ds which had been grounded in 1963. The work included building and fitting new wings, and also converting the aircraft for electronic reconnaissance and countermeasures work. They re-entered

EB-57D 53-3966 of 4677 Defense Systems Evaluation Squadron. This aircraft was built as an RB-57D, the enlarged engine nacelle and nose radome of this version being readily apparent. (*MAP*)

B-57E 55-4295 after conversion to EB-57E standard. The underwing chaff dispenser pods and fuselage aerials are the only external evidence of the modifications for electronics work.

service in 1966 with the designation EB-57D, and were intended to have at least eight years service life. All the aircraft were used by 4677 Defense Systems Evaluation Squadron which was one of three which operated B-57 variants. These squadrons, the 4677 DSES, 4713 DSES and 4758 DSES, were all based in the USA, although a detachment of 4713 DSES was usually in Germany. All DSES B-57s were specially adapted for electronic work, EB-57A, EB-57B and EB-57E aircraft being used in addition to EB-57Ds.

Some of the Air National Guard B-57 squadrons were re-equipped in 1968 and 1969, three squadrons having received F-101 Voodoo aircraft by the end of 1968. During 1969 the two B-57 squadrons which had been in Vietnam since 1965 left for other bases. One squadron, 13 TBS, returned to the USA, and was stationed at MacDill AFB, Florida. The squadron retained its B-57B and B-57C aircraft. The second squadron, 8 TBS, remained in the Far East, moving to Clark AFB in the Philippines. There the unit was equipped with EB-57Es for electronics work. Another EB-57E squadron in the Far East at this time was 556 Reconnaissance Squadron, based in Japan. The South Vietnamese Air Force operated a few B-57Bs in 1964 and 1965, these aircraft being returned to the USAF in rotation for servicing and overhaul.

In 1968, work started on a new version of the B-57 designated B-57G. Experience in Vietnam had indicated a need for an aircraft capable of finding and attacking small slow-moving targets, such as vehicles, at night. An order for sixteen B-57Gs was placed, Westinghouse being the main contractor, with aircraft modification and installation work being sub-contracted to Martin. The B-57Gs were derived from B-57Bs, which were completely refitted and re-equipped, at a cost of about three million dollars per aircraft. Highly sophisticated electronic equipment was fitted to enable small targets to be found and attacked by night. A forward-looking radar and an infra-red detection system were used to find the target, the radar also being used for ground mapping and to provide navigation and terrain avoidance data. The primary armament was a 20 mm cannon turret, mounted under the centre fuselage and coupled with a laser range-finder. The crew were able to view the target by means of low light level television, which was effective even in the absence of moonlight. The laser range-finder could also be used to mark the target for attack by laser seeking weapons, or for other aircraft with laser seeking devices. The first two B-57G conversions had been completed by early 1970, and these aircraft were used for acceptance trials. Operations over Vietnam started in September 1970, the 13 Bomb Squadron (Tactical) based at Ubon, Thailand, being equipped with 11 aircraft. The B-57Gs served in South East Asia until April 1972, when they were withdrawn to the United States, serving with an ANG squadron for a further two years before being withdrawn from service.

Early in 1969 a research project jointly undertaken by Britain and the USA brought together a B-57 and a Canberra. The aircraft concerned were 13300, an RB-57F of 57 WRS, and WH793, the prototype Canberra PR.9, from the Royal Aircraft Establishment. Both were based at Tengah, Singapore, for five weeks. During this time they made numerous high-altitude flights over and around tropical thunderstorms, gathering data on the clear air turbulence found near these storms.

During the early 1970s seven of the units flying B-57s were disbanded or re-equipped, leaving just three. Only one, the 17 DSES at Malmstrom Air Force Base, Montana, was a USAF unit. The other two were both Air National Guard squadrons, the 117 DSES (Kansas ANG) and the 134 DSES (Vermont ANG). All three DSES were equipped with EB-57Es, and were primarily engaged in providing electronic warfare training for all United States armed forces, particularly the flying services. In 1978 the 117 DSES was deactivated, followed in 1979 by 17 DSES. The latter unit was the last B-57 unit in the USAF, this event marking the end of 24 years service with the USAF. The remaining unit, the 134 DSES, Vermont ANG, based at Burlington, thus became the last squadron-size United States B-57 operator. The end came in 1982 when 134 DSES re-equipped with F-4D Phantoms. The remaining B-57s were all retired to the Davis-Monthan storage and disposal centre, where nearly all of the B-57s withdrawn in earlier years had ended their days. However, conversion to scrap usually followed some years in storage, and in 1983 over 50 aircraft were present, including nine different variants, although EB-57Es and WB-57Fs were the most numerous. By 1986 the number was down to 30, still including the WB-57Fs, and many of the EB-57Es. However, not all the aircraft sent to Davis-Monthan were scrapped or stored, for a number of individual aircraft went to various government and industry agencies, where they continued to fly in support of research and development work. Some of these aircraft will continue flying into the 1990s. Other surviving aircraft were those preserved as display items or museum exhibits; such aircraft numbered about 20 by the mid-1980s.

Throughout the Service lives of the B-57 and the Canberra there were numerous parallel developments and useages. The final parallel was that the last Service unit in both the USA and Britain will be an electronic warfare training squadron. Both the B-57 and the Canberra proved over the years to be exceptionally versatile, and this characteristic has been largely responsible for the unusually long Service lives of both types.

Martin RB-57A, B-57B, RB-57D and RB-57F. Powerplant: RB-57A, B-57B, two 7,220 lb st Wright J65-W-5; RB-57D, two 10,500 lb st Pratt & Whitney J57-P-27; RB-57F, two 18,000 lb st Pratt & Whitney TF33-P-11 and two 3,300 lb st Pratt & Whitney J60-P-9.

	RB-57A	B-57B	RB-57D	RB-57F
Span	63ft 11½in	63ft 11½in	106ft 0in	122ft 5in
Length	65ft 6in	65ft 6in	67ft 10in	68ft 10in
Height	15ft 7in	15ft 7in	15ft 7in	20ft 6in
Wing area	960sq ft	960sq ft	1,435sq ft*	1,850sq ft*
Empty weight	24,300lb	27,000lb	27,300lb	36,900lb
Normal loaded weight	48,600lb	53,700lb	45,000lb*	63,000lb*
Maximum loaded weight	51,500lb	56,950lb	—	—
Maximum speed at sea level	530mph	530mph	—	—
Maximum speed at high altitude	600mph	600mph	590mph*	—
Maximum operational altitude	47,000ft	47,000ft	70,000ft*	90,000ft*
Normal maximum range	2,300miles	2,300miles	3,000miles*	4,000miles*

*Approximate figures.

Armament and stores carried:
RB-57A: Flares carried internally.
B-57B: Up to 5,000 lb of various types of bombs carried in rotary bomb-bay; eight 0.5 in machine-guns or four 20 mm cannon mounted in wings; external stores carried on pylons include up to eight 5 in rockets, 500 lb bombs and napalm tanks.
RB-57D, RB-57F: Photographic and electronic reconnaissance equipment, full details not available.
Other variants: All are derived from the B-57B, specification differences being as described in the text.

Appendix C

Projected Aircraft

This appendix lists 91 known aircraft projects covering the period 1916–63. Very few of them were built. Among the companies which amalgamated to form English Electric only the Coventry Ordnance Works and the Phœnix Dynamo Co appear to have undertaken project work. Unfortunately, no record of COW's projects has survived, although it was claimed in a brochure published by COW that a number of landplanes and seaplanes were designed before the 1914–18 war.

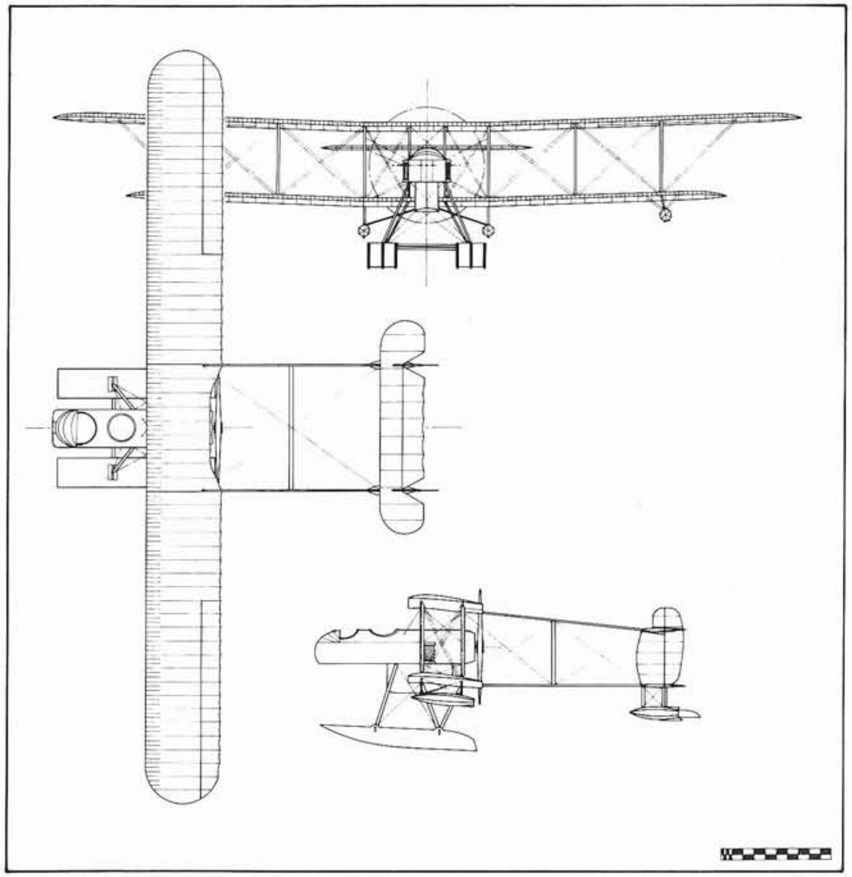
Project numbers were allotted but were duplicated, and the authors, therefore, have grouped the projects by company and date to avoid confusion. In the majority of cases the project number was prefixed by the letter P, which, depending on the period it was used, was an abbreviation for Phœnix (1916–18), patrol (1919–26) or project (1944 onwards). Other letters used, particularly by Manning, were: A or C, civil aeroplane; L, light aeroplane; M, military flying-boat and S, sports or training aeroplane. Many of Manning's projects were un-numbered and undated,

and only by recourse to the jottings in his notebooks relating to appointments, telephone conversations etc, have the authors been able to put the projects in chronological order. For completeness project numbers given to aircraft which were built have been included in the list. Types marked with a dash had no type numbers but appear here in correct sequence.

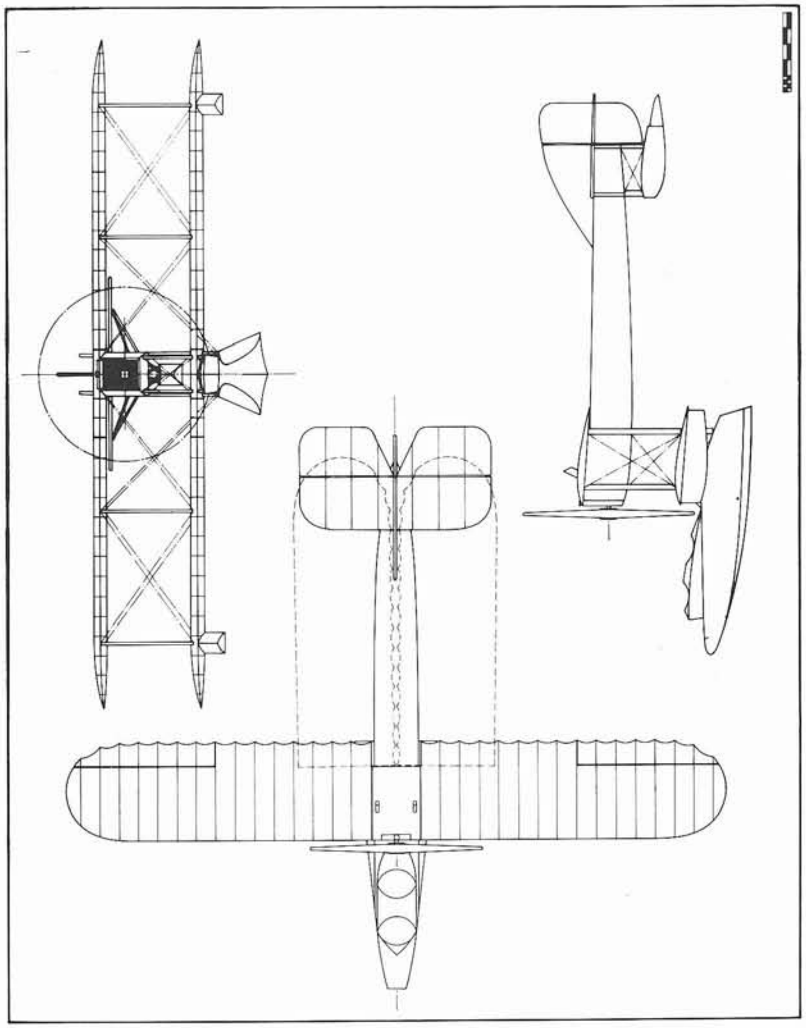
During the second phase of English Electric's history, that is from mid-1945, most project work was the responsibility of R. F. Creasey. In addition, he often had responsibility for many other departments and some projects, therefore, were discontinued after little more than a preliminary drawing had been produced and a few calculations made.

Phœnix Dynamo Manufacturing Co Ltd (October 1916–December 1918).

P.1 Twin-float two-seat pusher seaplane powered by one 200 hp Sunbeam engine. Four bombs were carried vertically inside a



Phœnix P.1.



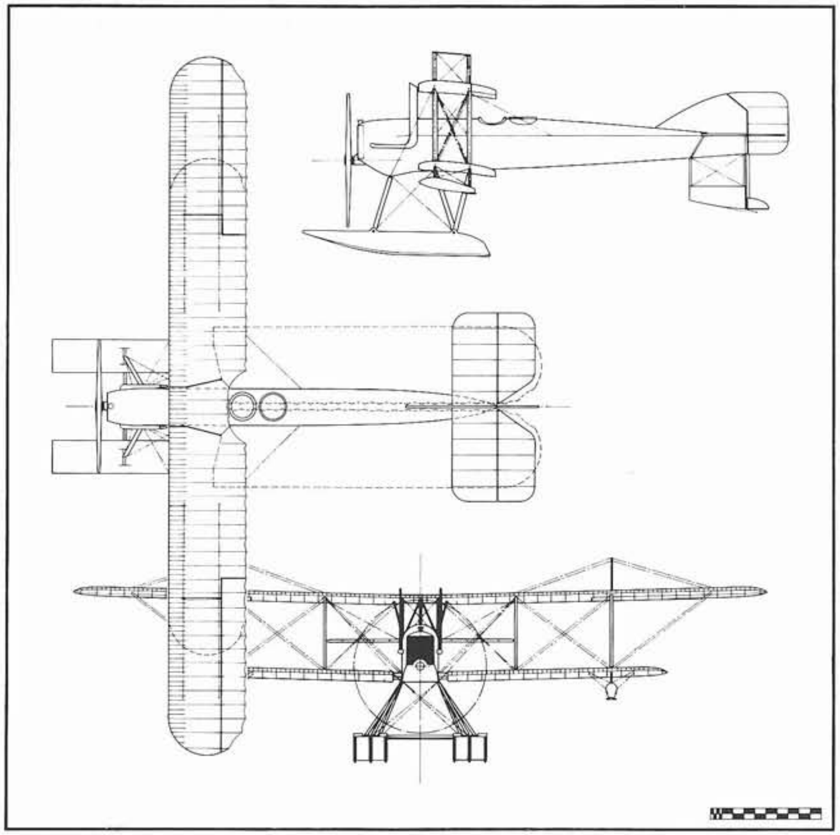
Phœnix P.2.

streamlined fairing below the crew nacelle. Bomb load 400 lb. Span 67 ft 9 in; length 34 ft; wing area 825 sq ft. Weight loaded 4,220 lb. Maximum speed 69 mph; climb to 6,500 ft, 30 min.

— Twin-float two-seat seaplane powered by two 130 hp Clerget rotary engines. Bomb load 220 lb. Span 49 ft 4 in; wing area 488 sq ft. Weight loaded 3,415 lb.

P.2 This project number was given to two machines. Both designs were prepared to specification N.2b under an Admiralty contract signed in 1917. The machines were allocated serial numbers N22 and N23. Each machine had a crew of two and was powered by one 200 hp Hispano-Suiza engine. Armament consisted of one fixed Vickers gun for the pilot and a Lewis gun for the observer. Three 65 lb bombs were carried.

The first design was a tractor type which had a two-tier fuselage. The upper part carried the engine and tail unit and was attached to the lower hull by extensions of the centre-section interplane struts. Span 42 ft 3 in; length 33 ft; height 11 ft 6 in;



Phœnix P.3.

wing area 510 sq ft. Weight loaded 3,315 lb. Maximum speed 91 mph; climb to 10,000 ft, 28 min.

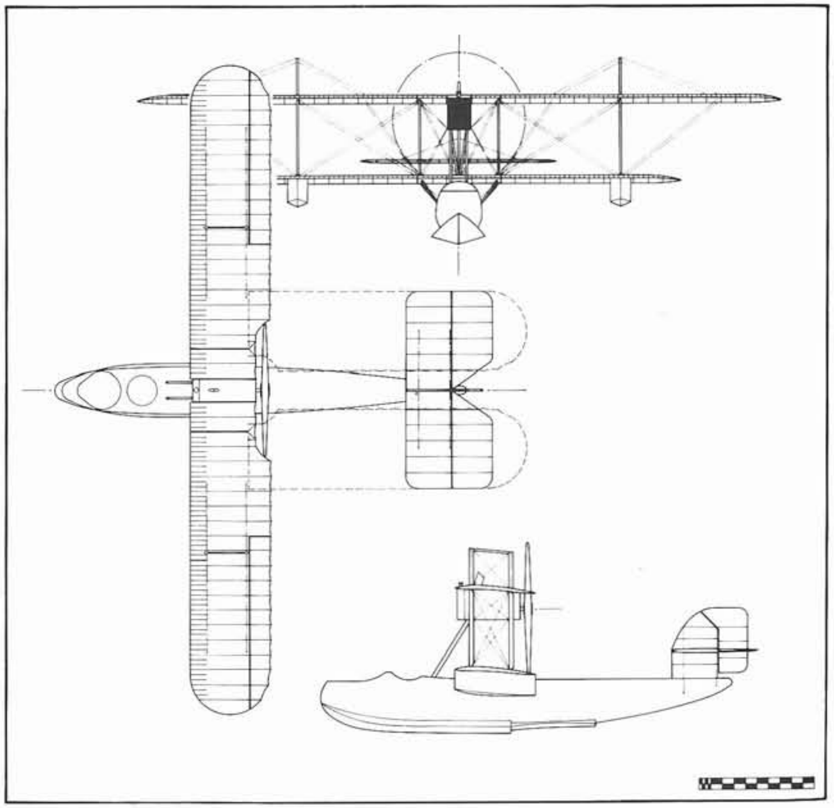
The second design was a twin-float pusher seaplane.

P.3 Twin-float two-seat tractor seaplane designed to specification N.2b and closely resembling Short Type 184. Powered by one 350 hp Rolls-Royce Eagle engine. Span 56 ft 10 in; wing area 765 sq ft. Weight loaded 5,350 lb. Maximum speed 98 mph; climb to 6,000 ft, 15 min.

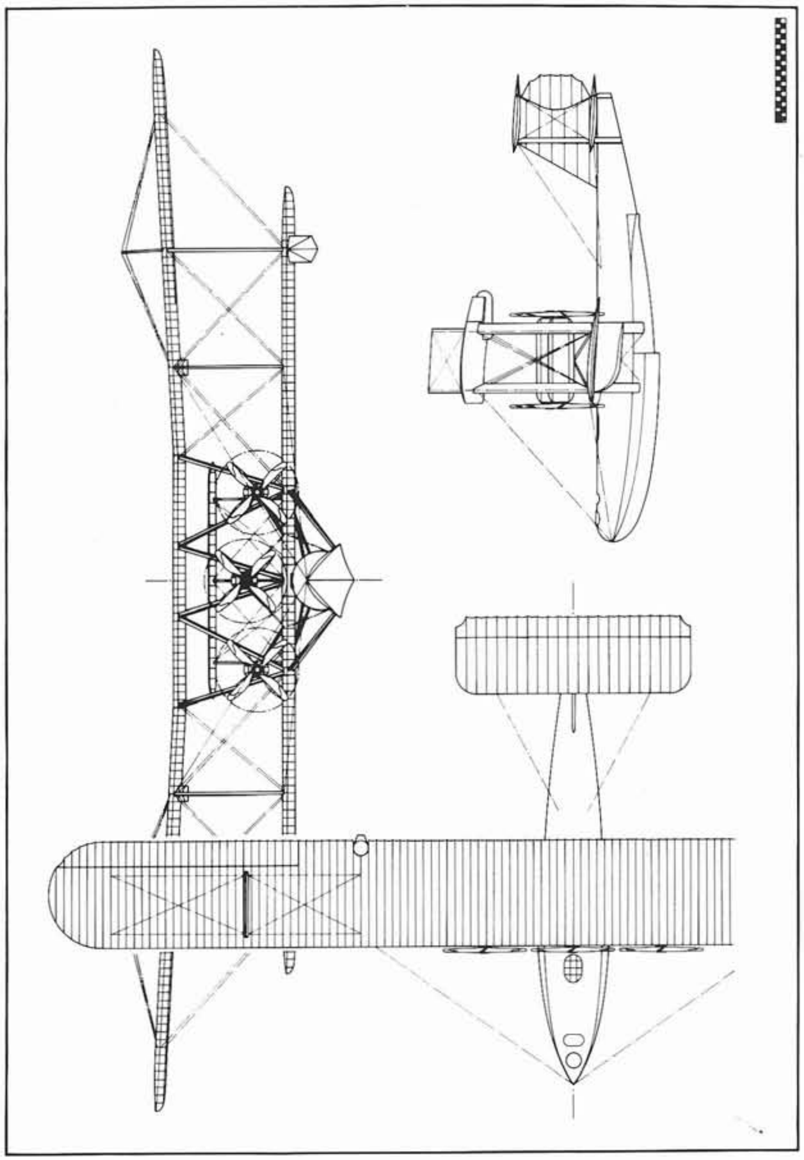
P.4 Two-seat pusher flying-boat with Linton Hope hull powered by one 275 hp Sunbeam Maori engine. Originally designed to specification N.2b, it was modified in 1919 to take three or four seats, and under the name Grey Mullet was suggested as a suitable aircraft for the private owner. Armament: one Lewis gun, four 100 lb bombs. Span 55 ft 11 in; length folded 41 ft; wing area 660 sq ft. Weight loaded 4,630 lb. Maximum speed 95 mph; climb to 6,000 ft, 22 min; endurance 4 hr.

P.5 Cork (*qv*).

— Triplane flying-boat powered by six engines of 800 hp each. Span



Phœnix P.4/English Electric Grey Mullet.



Phœnix P.6 Pulex.

176 ft; wing area 8,450 sq ft. Weight loaded 76,000 lb.

P.6 Pulex.* Anti-submarine patrol flying-boat powered by six 600 hp Rolls-Royce Condor engines mounted in tandem pairs and driving tractor and pusher propellers. Six crew. Bi-, tri-, quadru- and quintoplane arrangements were considered but the first was adopted for the final design, together with a biplane tail unit having a large central fin and twin outboard rudders. The hull was to be of Linton Hope construction. Armament envisaged: twin-Lewis guns at bow and upper wing nacelles and six 500 lb bombs carried below the lower wing-root. In 1919 the Pulex was offered for civil use, in which role it was intended that it carry 40 passengers or 11,200 lb of freight. Span 201 ft 6 in; length 88 ft 9 in; height 44 ft 6 in; wing area 7,077 sq ft. Weight loaded 65,000 lb. Cruising speed 100 mph at sea level; climb to 6,000 ft, 26 min; range 800 miles; endurance 8 hr at cruising speed. January 1918.

P.7 Eclectic.* Long-range civil flying-boat possibly designed to a specification issued by the Royal Mail Steam Packet Co. The Eclectic was intended to carry 50 passengers each with a luggage allowance of 50 lb, or 14,650 lb of freight. Passengers were allowed ample room to move about in luxuriously fitted cabins, which included dining and smoking rooms, the latter being of fireproof construction and built on top of the hull. Sleeping births were also provided for use on long journeys. The flying-boat was powered by eight 600 hp Rolls-Royce Condor engines geared together in two groups of four, each group driving one tractor propeller of 25 ft diameter. Some experimental work was conducted and included the design of steel spars and an investigation into the use of steam turbine-driven propellers. Span 248 ft 6 in; length 103 ft 6 in; height 51 ft 6 in; wing area 10,000 sq ft. Weight loaded 100,000 lb. Cruising speed 80 mph; range 1,600 miles; endurance 20 hr at cruising speed. December 1918.

— Investigation into the performance of the P.5 Cork in connection with the £10,000 prize offered by the *Daily Mail* for the first direct transatlantic flight.

P.8 Civil conversion of the P.5 Cork to carry 10 passengers.

The English Electric Co Ltd (January 1919–April 1926).

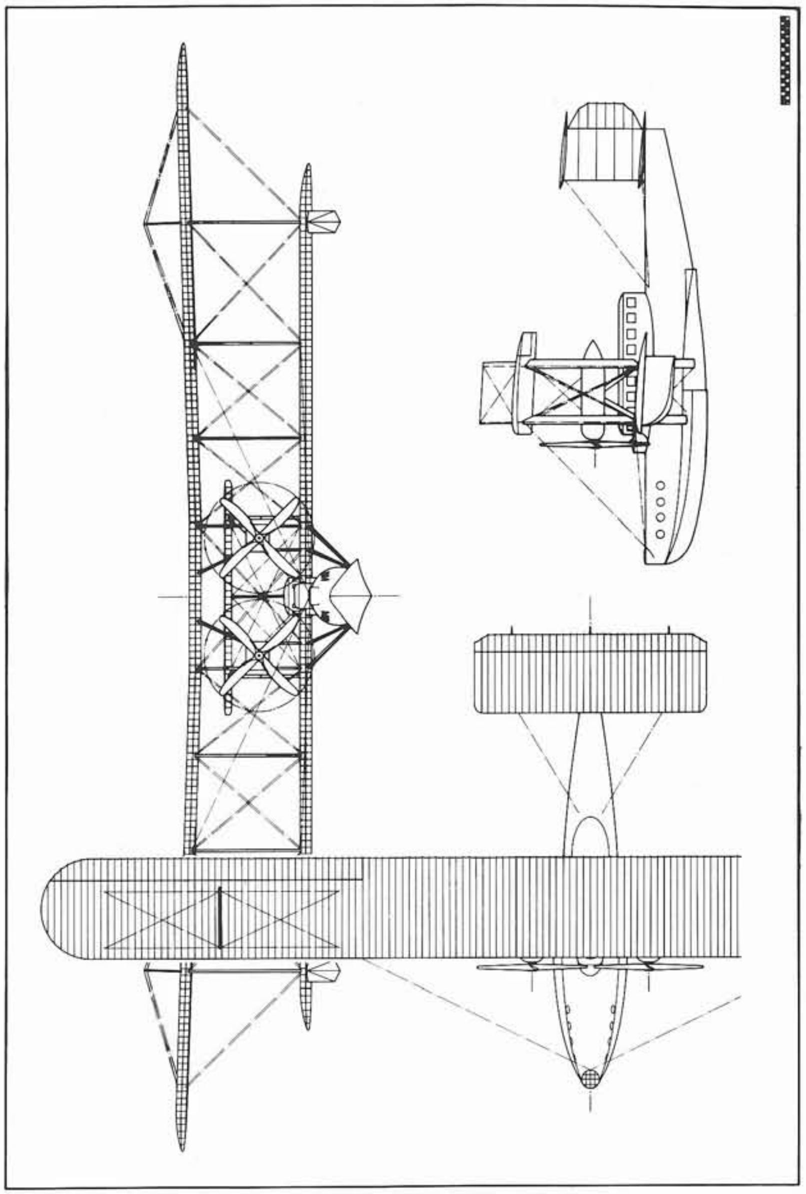
P.9 Flying-boat powered by three 600 hp Rolls-Royce Condor engines. Span 152 ft; wing area 3,622 sq ft. Weight loaded 36,000 lb.

P.10 Six design studies for amphibious two-seat aeroplanes armed with one Vickers machine-gun and one Lewis gun.

a) Twin-float triplane. Mono-, bi- and quadruplane versions also considered. One 275 hp Rolls-Royce Falcon. Span 36 ft; wing area 523 sq ft. Weight loaded 4,180 lb.

b) Twin-float biplane. One 320 hp ABC Dragonfly. Span 36 ft; wing area 504 sq ft. Weight loaded 4,030 lb.

* W. O. Manning's notebooks of that time state clearly that the design illustrated as the Eclectic in the English Electric brochure, *Transport by Aircraft*, published in 1919, was in fact the Pulex and vice versa.



Phœnix P.7/English Electric Eclectic.

c) Biplane flying-boat. One 275 hp Rolls-Royce Falcon. Weight loaded 3,840 lb.
d) Biplane flying-boat. Triplane version also considered. One 320 hp ABC Dragonfly. Span 36 ft; wing area 458 sq ft. Weight loaded 3,670 lb.
e) Twin-float biplane. One 320 hp ABC Dragonfly. Span 40 ft; wing area 613 sq ft. Weight loaded 4,600 lb. June 1919.
f) Twin-float biplane. One 400 hp Cosmos Jupiter. Span 40 ft. Weight loaded 4,460 lb. July 1919.

P.11 Biplane flying-boat. Three crew. Two 500 hp Cosmos Jupiter. Span 104 ft 6 in; wing area 1,701 sq ft. Weight loaded 16,000 lb. Maximum speed 98 mph.

P.12 Four-seat civil biplane flying-boat or seaplane, both powered by one 350 hp engine. Span 57 ft 8 in; wing area 834 sq ft. Weight loaded 7,110 lb. Maximum speed 92 mph.

— Torpedo Bus. Biplane flying-boat, resembling Sopwith Bat Boat, powered by one 1,000 hp steam turbine. Two torpedoes carried below lower wing-root. Span 127 ft 4 in; wing area 2,790 sq ft. Weight loaded 28,000 lb.

M.1 Preliminary design for M.3 Ayr (*qv*).

M.2 Amphibious version of M.1.

M.3 Ayr (*qv*). July 1921.

P.5 Kingston (*qv*). August 1922.

A.1 Civil flying-boat based on M.3 Ayr. Powered by eight 1,000 hp Napier Cub engines geared together in two groups of four, each group driving one tractor propeller of 30 ft diameter. Span 146 ft; length of hull 102 ft; height 33 ft; wing area 2,450 sq ft. Weight loaded 120,000 lb.

— Investigation into use of P.5 Kingston for postal services across the Irish Sea and the English Channel. Comparisons of performance made with Rolls-Royce and Napier engines fitted to the Kingston.

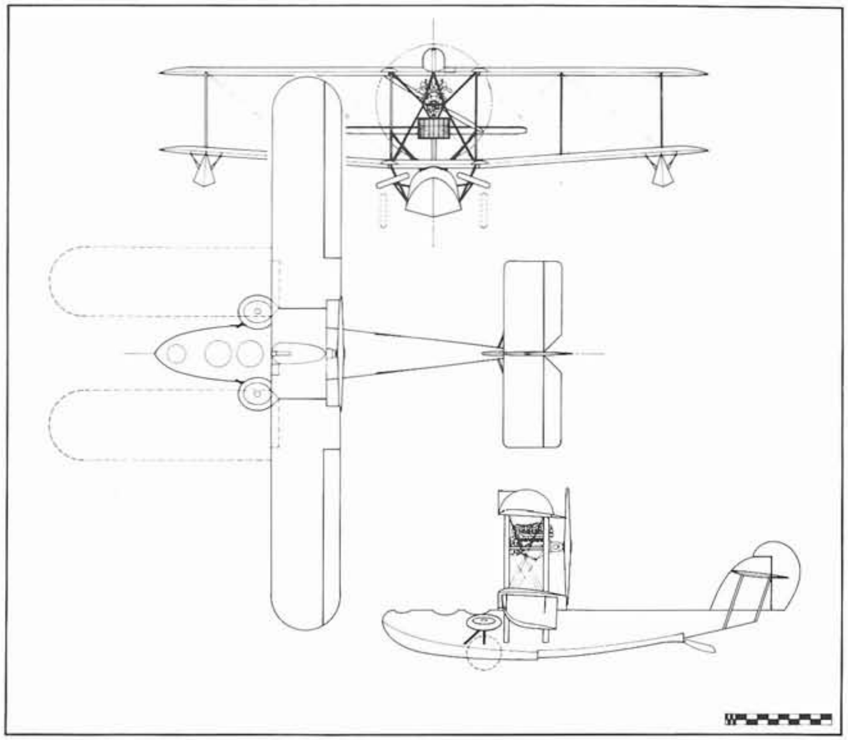
— Civil flying-boat seating six passengers and pilot, and powered by one 360 hp Rolls-Royce Eagle VIII. Biplane layout with Linton Hope hull of rectangular cross-section. Span 90 ft 6 in; wing area 586 sq ft. Weight loaded 5,260 lb.

S.1 Wren (*qv*). October 1922.

— Aeroplane for the Chilean Government powered by two Napier Lion or Rolls-Royce Condor engines. Armament included bomb load of 3,000 lb or torpedoes. Weight loaded 20,000 lb.

P.6 Biplane flying-boat to specification N.3. Two Rolls-Royce Condor engines. Five crew. Armament: four Lewis guns and bomb load of 1,000 lb. Span 101 ft; wing area 1,872 sq ft. Weight loaded 19,700 lb. Cruising speed 92 mph; range 1,500 miles.

P.7 Three-seat amphibian flying-boat for Canadian Government. Intended for patrol work and operation from small aerodromes, lakes, rivers, etc. Provision made for Scarff ring mounting at bow position. Biplane layout with Linton Hope hull. Wheels of amphibious undercarriage could be replaced by snow skis. P.7 was powered by one 360 hp Rolls-Royce Eagle driving a pusher propeller. Span 52 ft; length 39 ft 6 in; height 17 ft; wing area 704



English Electric P.7.

sq ft. Weight loaded 5,120 lb. Maximum speed 95 mph; climb to 5,000 ft, 11 min 30 sec; endurance 6 hr; service ceiling 11,000 ft.

S.2 Two-seat training or touring aircraft based on the Wren. One 32 hp Bristol Cherub. Span 45 ft; length 27 ft; height 5 ft 6 in. Weight loaded 760 lb. Maximum speed 58 mph; initial rate of climb 170 ft/min; endurance 4 hr.

— Single-seat sports monoplane for the Air League of the British Empire. Biplane version also considered. One 25 hp Douglas Sprite. Span 28 ft 9 in; wing area 138 sq ft. Weight loaded 620 lb.

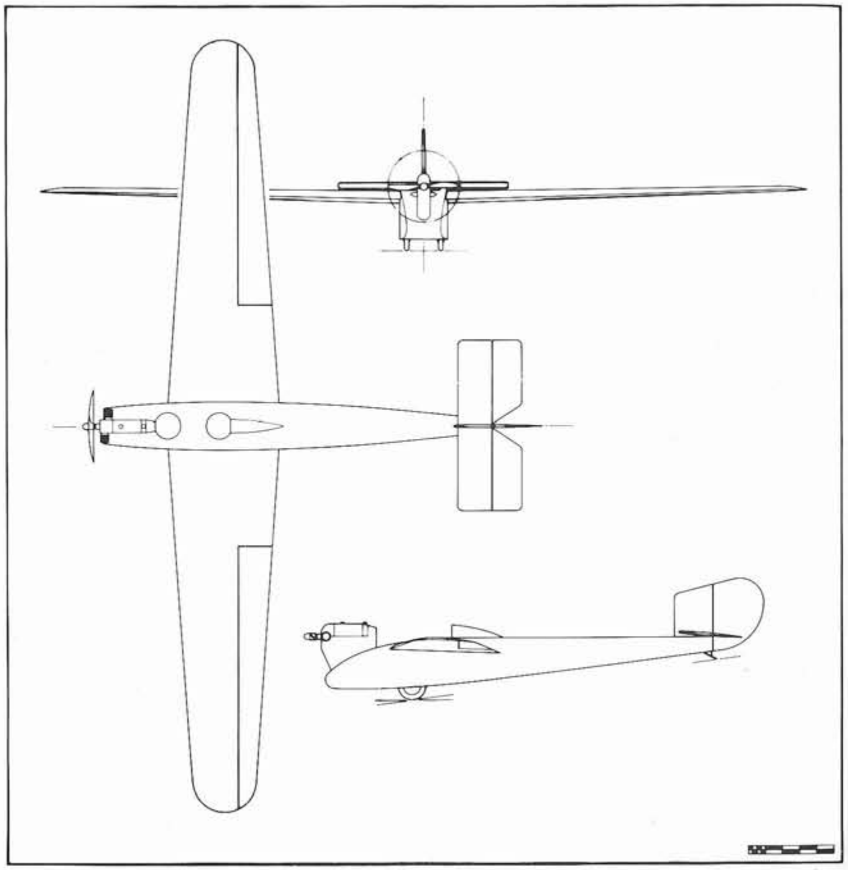
— Twen. Twin-engine version of the Wren. Two 9 hp Villiers motor-cycle engines. Weight loaded 590 lb.

C.1 Civil biplane seating eight passengers and two crew for Middle East air routes. One Rolls-Royce Condor, Cosmos Jupiter or Napier Lion engine. Span 84 ft; wing area 1,000 sq ft. Weight loaded 11,880 lb.

— 'Special Machine'. Three-seat single-engine monoplane. Span 48 ft. Weight loaded 1,510 lb. Maximum speed 82 mph.

— Three-seat amphibian powered by one Armstrong Siddeley Jaguar or Cosmos Jupiter.

P.8 Military flying-boat to specification 9/23. Three 470 hp engines. Armament: three Lewis guns and bomb load of 1,000 lb. Span 102



English Electric S.2.

ft 6 in; wing area 1,916 sq ft. Weight loaded 19,120 lb. May 1923.

— Duralumin hull for P.5 Kingston Mk II. Designed to specification GE 89 issued in April 1923.

— Single-seat fighter armed with one Vickers machine-gun. One 150 hp engine. First English Electric design to incorporate oxygen equipment for the pilot. Wing area 81 sq ft. Weight loaded 4,500 lb. Maximum speed 200 mph.

L.1 Twin-float single-seat biplane powered by one 50 hp engine. Wings were cantilevered from centre-section. Span 20 ft 11 in; wing area 147 sq ft. Weight loaded 1,000 lb. Design shelved November 1924.

C.2 Civil biplane seating 18 passengers. Three 380 hp Bristol Jupiter engines. Span 101 ft 6 in; wing area 1,150 sq ft. Weight loaded 17,260 lb. Maximum speed 106 mph; initial rate of climb 500 ft/min; endurance 4½ hr.

— Twin-float training biplane. One 480 hp radial engine. Wing area 562 sq ft. Weight loaded 5,240 lb.

— Two-seat flying-boat for Canadian market. One 180 hp Armstrong Siddeley Lynx engine. Span 42 ft 9 in; wing area 427 sq ft. Weight loaded 2,800 lb.

— Two-seat single-engine biplane fitted with dual control. Span 29 ft; wing area 240 sq ft. Weight loaded 1,230 lb. Maximum speed 80 mph.

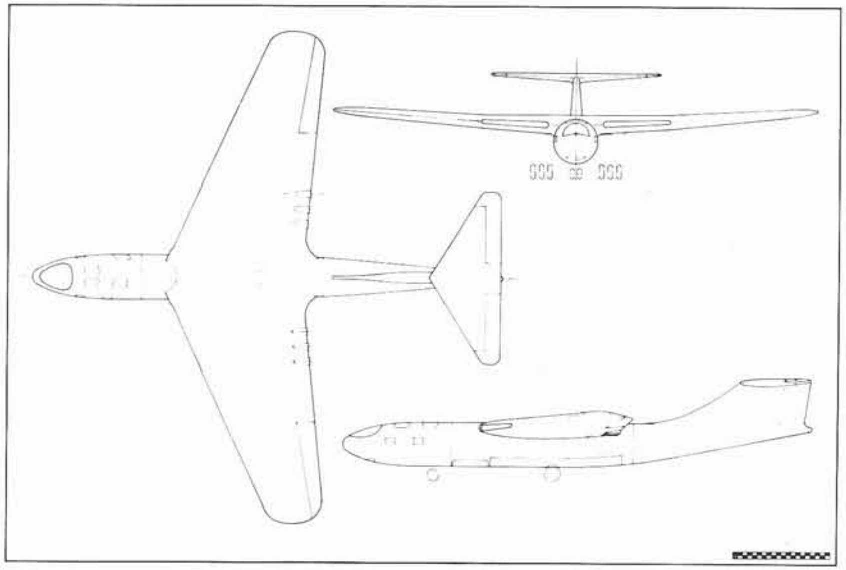
— Twin-float photographic reconnaissance biplane. Two 180 hp engines. Span 54 ft 5 in; wing area 844 sq ft. Weight loaded 5,900 lb.

At this juncture Manning's personal records apparently end. The authors assume that there must have been more notes as Manning remained with the Company at least until April 1926, and no mention was made of the Kingston Mk III. The earliest record of this flying-boat appears in May 1925, when the NPL published the results of tests with a hydrodynamic model of its hull. From this fact the authors conclude that Manning's notes cease sometime before May 1925.

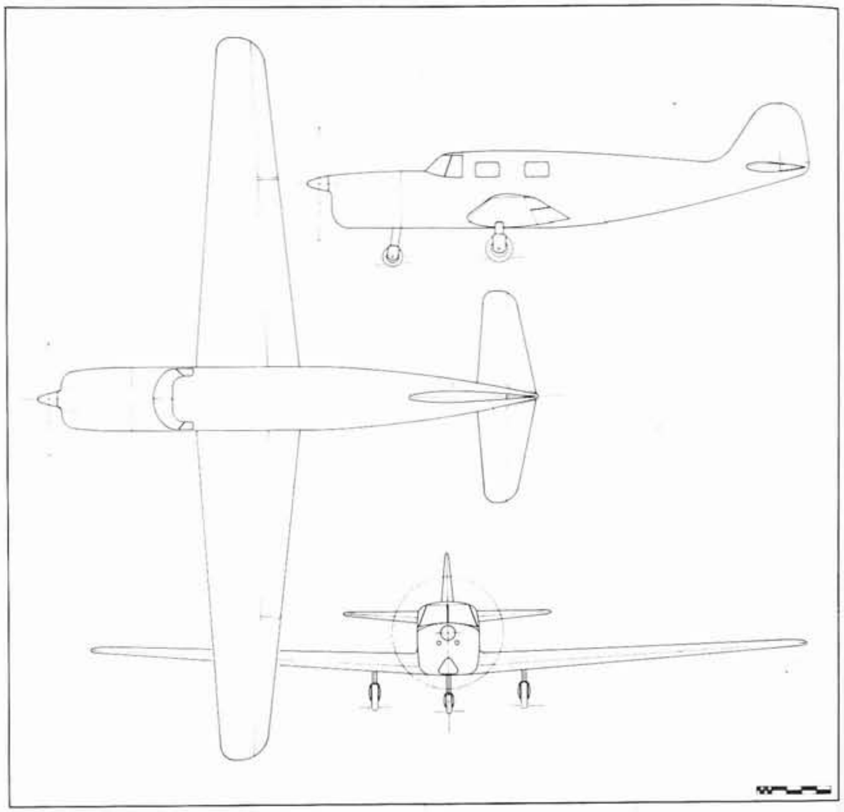
The English Electric Co Ltd (July 1945–January 1964)

— Canberra (*qv*).

— Bomber to specification B35/46. High-wing unarmed aircraft designed to meet both OR 229 and OR 230 issued for medium-range and long-range bombers respectively. The long-range variant used the airframe of the medium-range version but had increased internal fuel tankage and jettisonable wingtip tanks.



English Electric bomber to specificaton B35/46.



English Electric replacement for de Havilland Dragon Rapide (April 1948).

Five crew, all equipped with ejection seats. Powerplants were six 4,800 lb st Napier or Armstrong Siddeley axial-flow turbojets housed completely within the wing root. Maximum bomb load 20,000 lb. Span 100 ft; length 97 ft; height 21 ft 3 in; wing area 2,000 sq ft. All-up weight (medium-range version) 84,000 lb. Maximum speed 590 mph; maximum rate of climb 5,600 ft/min; medium range 3,900 miles; service ceiling 50,000 ft. March 1947-January 1948.

— Civil transport. Conventional layout with wing-mounted Bristol Proteus or Napier Nomad engines. December 1947.

— de Havilland Dragon Rapide replacement. Six-to-eight seat low-wing civil aeroplane powered by two engines geared to a single propeller. Engines considered were: Cirrus Major, Cirrus Musketeer, Gipsy Major or Gipsy Queen 30. Drawings were prepared for a mock-up before the design was shelved. March-June 1948.

P.1 Transonic research aircraft developed into Lightning (*qv*).

P.1A Designation retrospectively allotted to the two P.1 prototypes, WG760 and WG763.

P.1B Lightning F.1 and F.1A (*qv*).

P.2 Canberra for bomber intruder role. May 1950.

P.3 Development of P.1 with side intakes. March 1951.

P.4 Development of Canberra with redesigned nose. May 1951.

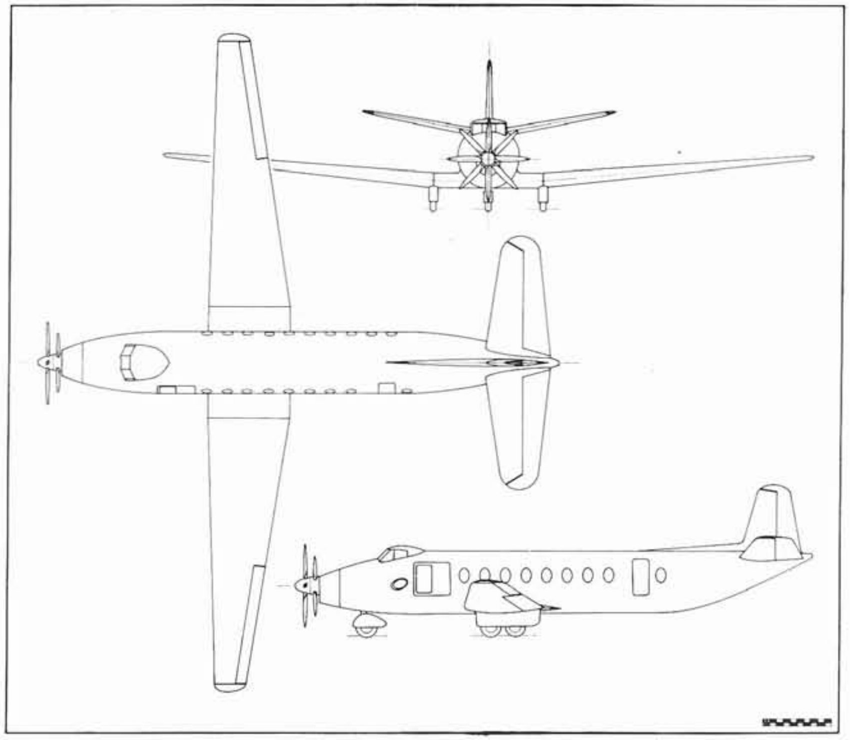
P.5 Development of P.1 with one Rolls-Royce Avon RA.12 with reheat. March 1952.

P.6 Various studies of Mach 2 research aircraft to specification ER.134T based on Lightning and other configurations. April-August 1953.

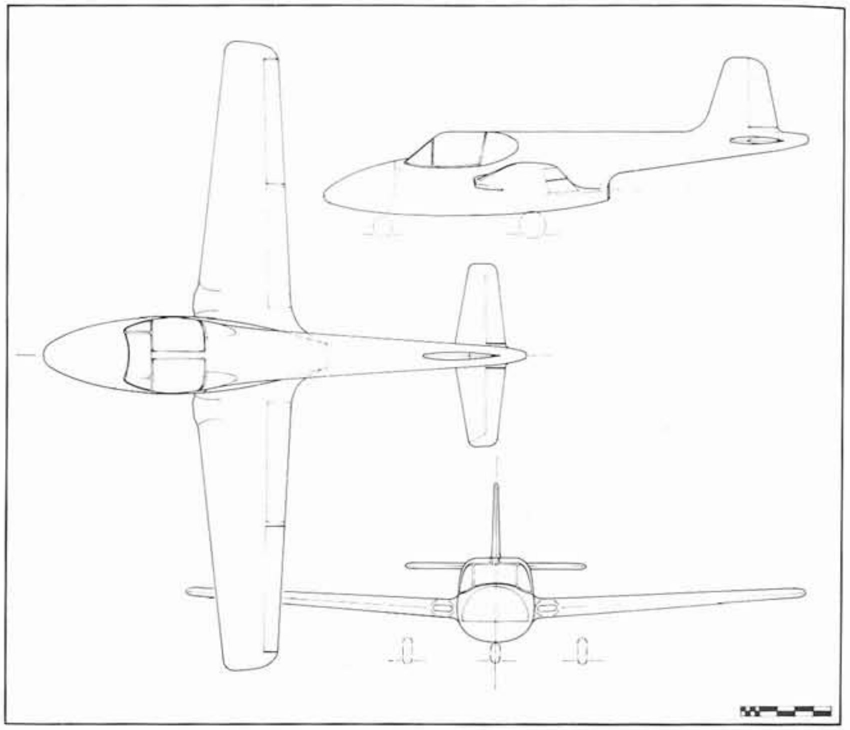
P.7 Douglas DC-3 Dakota replacement. Low-wing civil aircraft powered by one Armstrong Siddeley Double Mamba propeller-turbine. Designed for passenger/freighter or ambulance roles. June 1953.

P.8 High-altitude fighter based on Lightning. Designed to specification F.155T. Crew seated in tandem. Area-rule fuselage. Air-to-air missiles carried on wingtips. September 1955.

P.9 Basic jet trainer with pupil and instructor seated side-by-side. One 880 lb st Turboméca Marboré II. Design later used for initial



English Electric P.7.



English Electric P.9.

studies for BAC P.59 trainer in competition with Hawker Siddeley Hawk. June-October 1954.

P.10 Various studies of high-altitude Mach 3 reconnaissance aircraft to specification R.156T. Canard layout powered by two turbojets at the rear of the fuselage and a ram-jet wing. Wings carried jettisonable aerofoil-shaped tip tanks. Design features patented under Nos. 813692, 829873, 844847, 846382, 854859, 899625, 906499, 910350 and 965371. December 1955-March 1959.

P.11 Lightning T.4 (*qv*).

P.12 All-weather fighter variant of Canberra.

P.13 Guided weapon target variant of Canberra.

P.14 Military transport to OR 323.

P.15 Photographic-reconnaissance variant of Lightning. February 1956.

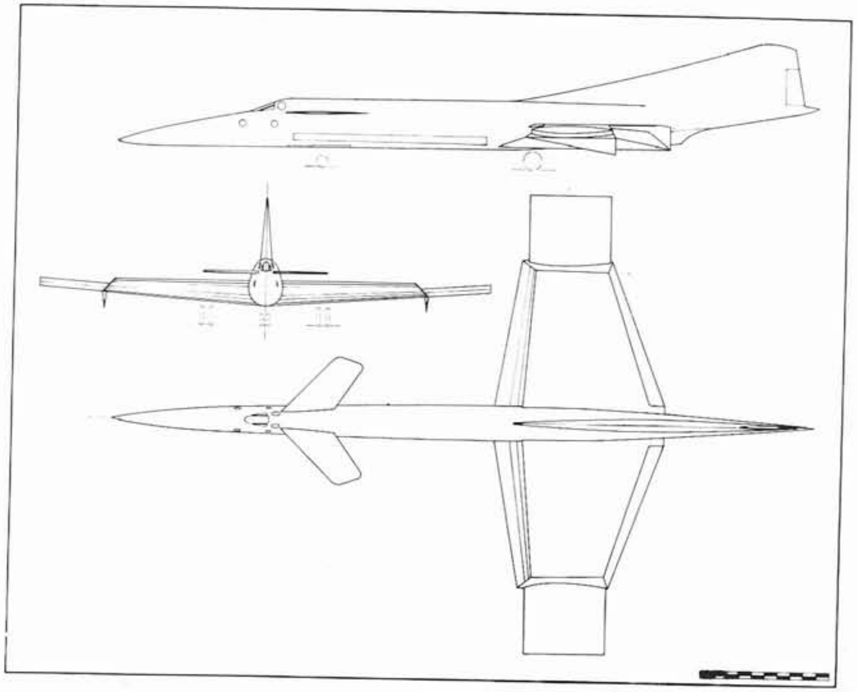
P.16 Night fighter variant of Canberra for Indian Air Force.

P.17 Study for tactical strike reconnaissance aircraft developed into P.17A.

P.17A Tactical strike reconnaissance aircraft to GOR 339. Design developed in conjunction with Vickers-Armstrongs to become BAC TSR.2 (*qv*).

P.17B STOL version of P.17A.

P.17C V/STOL version of P.17A.



English Electric P.10.

P.17D VTOL launcher platform for P.17A designed in conjunction with Short Bros & Harland Ltd. (Shorts' project No. PD.17). November 1957-January 1958.

P.17E VTOL version of P.17A.

P.17F VTOL launcher platform similar to P.17D using two jet-driven fans for propulsion. Civil version became one of studies under project No. P.20. March 1958.

P.17Z TSR aircraft of slender delta configuration.

P.18 Low-altitude bomber variant of Lightning. October-November 1956.

P.19 Interceptor variant of Lightning.

P.20 Various studies of VTOL civil transports seating about 100 passengers. Studies reconsidered under project No. P.24. January 1958.

P.21 Canberra PR.9 with two Rolls-Royce RB.133. August 1957.

P.22 Fighter variant of P.17A. February 1957.

P.23 Lightning variant.

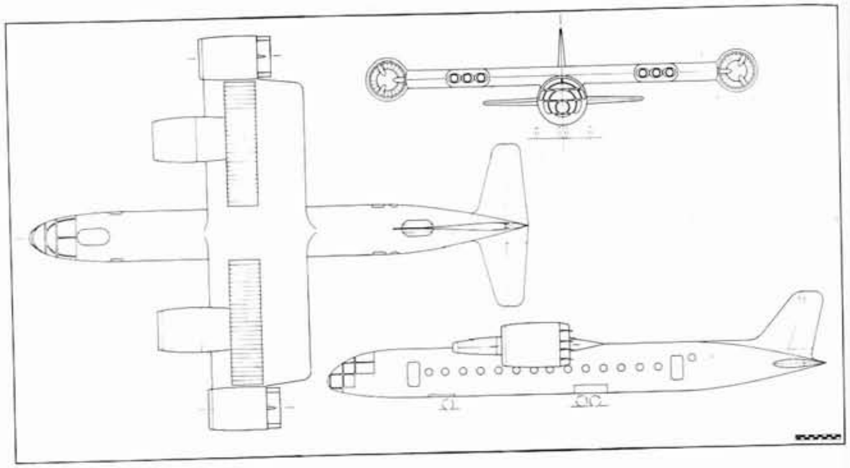
P.24 Various studies of VTOL civil transports developed from P.20. April-June 1958.

P.25 Lightning F.2 (*qv*).

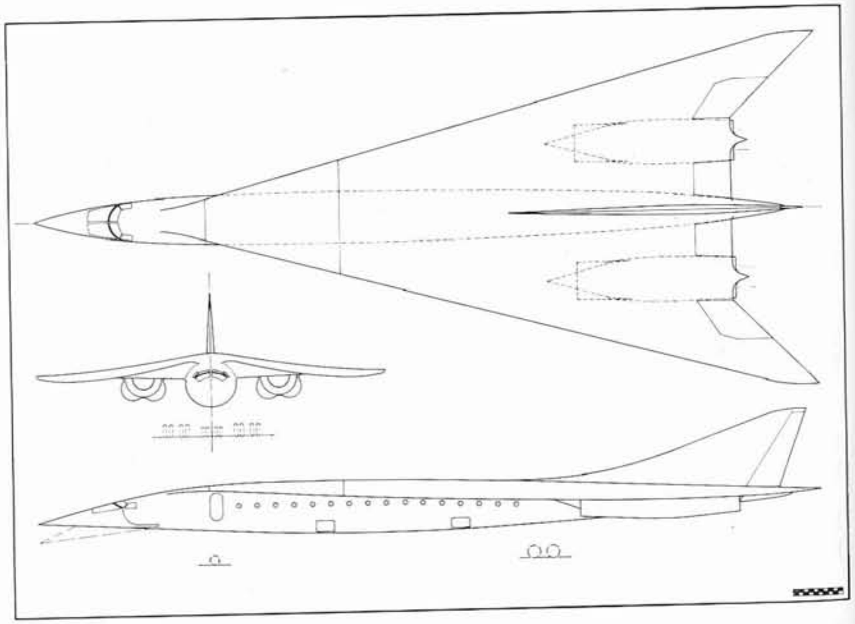
P.26 Lightning F.3 (*qv*).

P.27 Lightning T.5 (*qv*).

P.28 Clipped-wing variant of the Canberra.



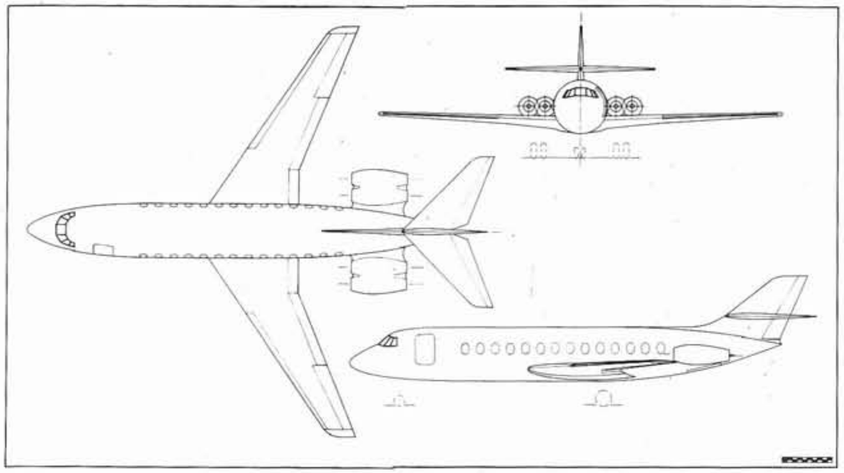
English Electric P.24.



English Electric P.30N.

P.29 High-wing civil transport powered by four wing-mounted podded jet engines. November 1958.

P.30 Various studies for supersonic civil transports for speeds up to Mach 3. Powered by four or six engines. Variable-geometry variants considered. February 1959-April 1960. (The company studied the outlook for economic quiet supersonic transports



English Electric P.32A.

earlier in 1956 and concluded then that such an aircraft was decades away. The company therefore abstained from early work in connection with the Supersonic Transport Aircraft Committee but became involved during the formation of BAC).

P.31 VTOL strike reconnaissance aircraft to GOR 2. Mid-1959.

P.32 Medium-haul jet transport for 52–56 passengers. Powered by two 10,100 lb st Rolls-Royce RB.163 Spey or four 5,000 lb st Bristol Siddeley BS.75 engines. Similar in layout to the later BAC One-Eleven, or Vickers VC10, but with tailplane mounted at mid-fin. Late 1959.

P.33 Lightning two-seat strike fighter to Australian requirement.

P.34 Lightning single-seat ground attack variant for RAF.

P.35 Flying reconnaissance vehicle to a British Army specification. Known as the 'Jumping Jeep', it was a high-performance cross-country fighting vehicle with air cushion ability over marshland or water. It also had the ability to leap obstacles by boosting the airflow to the cushion by fans driven by released stored energy. Testing of the concept's components had been done and prototypes were under consideration when the project was officially cancelled in November 1966.

P.36 V/STOL freighter to OR 351 and NATO requirement NBMR 4. 1960–1961.

P.37 STOL strike fighter for RAF and Royal Navy.

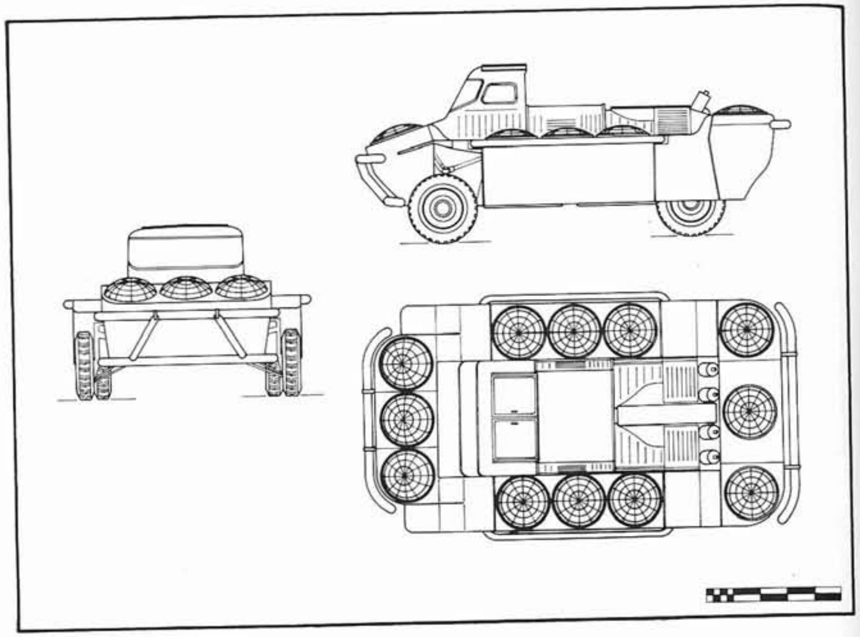
P.38 Bomber/reconnaissance variant of Canberra for South Africa.

P.39 VTOL strike fighter to NATO requirement NBMR 3. October 1961.

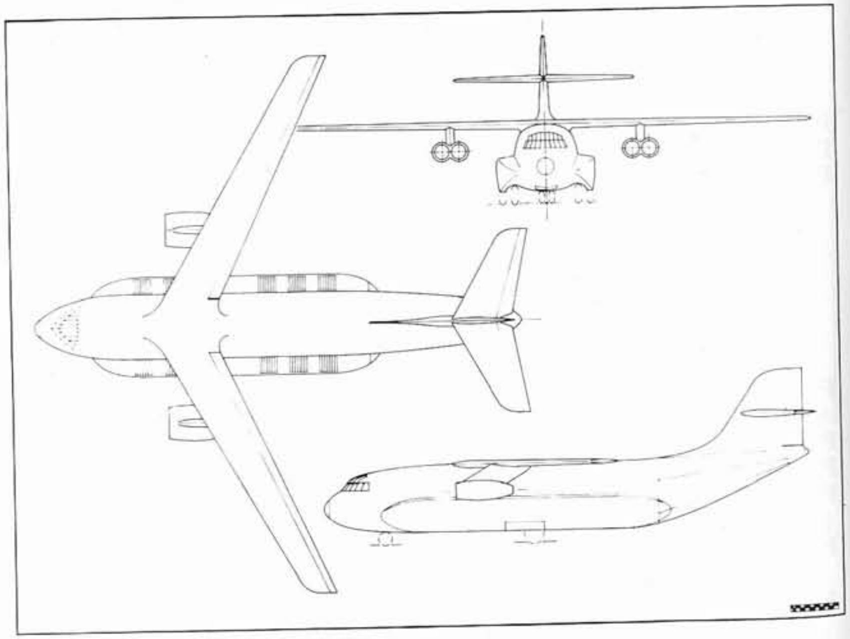
P.40 Various studies for a short-range transport powered by two turbojets or propeller-turbines. January-April 1962.

P.41 Military freight aircraft to NATO requirement NBMR 4 employing an air cushion undercarriage. July 1962.

P.42 Hypersonic research aircraft.



English Electric P.35.



English Electric P.36A.

P.43 Military freight aircraft to NATO requirement NBMR 22 employing an air cushion undercarriage. September 1962.

P.44 Various studies for V/STOL freight aircraft for the RAF and to NATO requirement NBMR 4. December 1962-January 1964.

P.45 Variable-geometry and fixed-wing comparative study for a single- or two-seat strike/trainer aircraft powered by one Rolls-Royce RB.168 Spey or two RB.172 engines. Formed the basis of BAC's contribution to the Anglo-French Variable Geometry aircraft project designed in conjunction with Avions Marcel Dassault. Late 1962-April 1965.

Appendix D

Summary of Aircraft Production and Service Use

This appendix provides data of contracts placed with and the Service use of aircraft designed by the English Electric Co Ltd and its predecessors between 1912 and 1964.

The Coventry Ordnance Works Ltd. Registered office and works: Stoney Stanton Road, Coventry, Warwickshire.

1912 Military Trials Biplane: Two built at Battersea. Allotted Trials Nos. 10 and 11. No. 10: Gnome engine; completed May 1912; rebuilt retaining Gnome engine late 1912. Modified No. 10: completed January 1913. No. 11: Chenu engine; completed July 1912.

Admiralty Type 54: One ordered to Contract No. CP 40633/13. Gnome engine. Serial No. 54.

The Phœnix Dynamo Manufacturing Co Ltd. Registered office and works: Thornbury Works, Bradford, Yorkshire.

Phœnix P.2 Seaplane: Two designs prepared to Admiralty specification N.2b. Hispano-Suiza engine. Allotted serial Nos. N22 and N23. Contract cancelled 1917.

Phœnix P.5 Cork: Contract No. AS 37016/17, dated 28 March, 1917, for two prototypes, N86 and N87. British requisition No. 256. C/ns 250 and 251 respectively. Originally ordered as experimental Felixstowe F.3s. Contract amended 28 November, 1917, to include N87. Hulls built by May, Harden & May Ltd. Rolls-Royce Eagle VIII engines. Mk I, N86: MAEE Isle of Grain 24 August, 1918. Mk II, N87: MAEE Isle of Grain June, 1919. Re-engined with Napier Lion IIb to become Mk III.

Phœnix P.5 Cork: Contract No. 38A/828/C.854, dated 10 October, 1918, for alteration of planing bottom of N87 to N86 standard. Alterations made 15 October–2 November, 1918.

Phœnix P.5 Cork: Contract No. PB 35A/166/C.66, dated 24 May, 1919, for recovering and doping of N87 wings.

The English Electric Co Ltd. Head office: Queen's House, Kingsway, London, W.C. 2. Works: Strand Road, Preston, and Lytham, Lancashire. (1918–26).

English Electric S.1 Wren: Contract No. AM/406094/23, dated 9 February, 1923, for one prototype, J6973. ABC engine. Price £600. Delivered AEE, Martlesham Heath, September 1923.

English Electric S.1 Wren: Two aircraft built for £1,000 *Daily Mail* Light Aeroplane Competition held at Lympne, Kent. Allotted competition Nos. 3 and 4. ABC engines. Price £350. No. 3: Registered G-EBNV April 1926. Withdrawn from service 1929. Cannibalised for parts for restoration of No.4, 1955. No.4: Delivered Science Museum, South Kensington, London, 1924. Returned to English Electric for restoration 1945. Restored using parts of No. 3 and handed over to Shuttleworth Trust, Old Warden, Bedfordshire, 15 September, 1957.

English Electric P.5 Kingston: Contract No. AM/333124/22, dated 20 January, 1923, for one prototype, N168. Napier Lion IIb engines. Crashed on take-off for first flight, 22 May, 1924.

English Electric P.5 Kingston: Contract No. AM/449553/23 for five aircraft: Mk I, N9709–N9712; Mk III, N9713. Napier Lion IIb engines. Wooden hulls. All aircraft delivered between November, 1924 and 16 March, 1926. MAEE, Felixstowe: N9709, N9713. RAE, Farnborough: N9712 (Hull only delivered in 1926 for structural testing). RAF Base, Calshot: N9710, N9711.

English Electric P.5 Kingston Mk II: Contract No. AM/433950/23 for one flying-boat with duralumin hull, N9712. Napier Lion IIb engines. Delivered MAEE, Felixstowe, 12 December, 1925.

English Electric M.3 Ayr: Contract No. AM/241097/21, dated 14 December, 1921, for two prototypes, N148 and N149. Napier Lion IIb engines. N149 not completed.

The English Electric Co Ltd. Head office: Queen's House, Kingsway, London, W.C. 2; later English Electric House, The Strand, London, W.C. 2. Works: Strand Road, Preston, Warton Aerodrome, near Preston, and Samlesbury Airfield, near Preston, Lancashire. (1938–64).

English Electric Canberra B.1: Contract No. 6/ACFT/5841/CB6(b), received 7 January, 1946, for four prototypes, VN799, VN813, VN828, VN850. First flight dates: 13 May, 1949, 9 November, 1949, 22 November, 1949, 20 December, 1949. Used for type development work and research.

English Electric Canberra B.2 and PR.3: Contract No. 6/ACFT/2000/CB6(b), received 1948, for four B.2 prototypes, VX165, VX169, VX173, VX177, and one PR.3 prototype, VX181. First flight dates: VX165, 21 April, 1950; VX169, 2 August, 1950; VX181, 19 March, 1951. Used for type development work and research. VX173 and VX177 transferred to first production contract as WD929 and WD930.

English Electric Canberra B.5: Contract No. 6/ACFT/4689/CB6(b), received 1950, for one prototype, VX185. First flight 6 July, 1951. Used for development work, later converted to B(I)8 prototype. First flight as B(I)8, 23 July, 1954.

English Electric Canberra T.4: Contract No. 6/ACFT/6265/CB6(b), received 1951, for one prototype, WN467. First flight 12 June, 1952. Used for type development work, later service with 231 OCU and 16 Squadron.

English Electric Canberra B.2, PR.3 and T.4: Contract No. 6/ACFT/3520/CB6(b), received March 1949, for 130 aircraft; comprising 88 B.2, WD929–WD966, WD980–WD999, WE111–WE122, WF886–WF892, WF907–WF917; 34 PR.3, WE135–WE151, WE166–WE175, WF922–WF928; eight T.4, WE188–WE195. Five B.2s added as replacements, WG788, WG789, WP514, WP515, XA536. One B.2 added in 1951, WV797. B.2 first flights: 8 October, 1950, to 21 August, 1952; PR.3 first flights: 31 July, 1952, to 10 January, 1954; T.4 first flights: 20 September, 1953, to 16 February, 1954. B.2 aircraft: No. 6 Sqn: WD936, WE111, WE113, WF914. No. 9 Sqn: WD990, WD997–WD999, WE111, WF907, WF908, WF916, WP514. No. 10 Sqn: WD965, WD980, WF892. No.12 Sqn: WD941, WD946, WD948, WD985-WD990, WD993–WD996, WF891, WF916, WP515. No. 15 Sqn: WD951, WD961, WD980. No. 27 Sqn: WD990, WD996. No. 32 Sqn: WD988, WD995. No. 40 Sqn: WD941, WD951. No. 44 Sqn: WD965, WD980, WD993, WF916. No. 45 Sqn: WD948, WD963. No. 61 Sqn: WD951, WD961. No. 73 Sqn: WD946, WD988, WD989, WF914, WP514. No. 85 Sqn: WD948, WD966, WP515, XA536. No. 98 Sqn: WD955, WE112, WE113, WE122. No. 100 Sqn: WD986, WD989, WF907. No. 101 Sqn: WD934, WD936, WD938, WD941, WD944, WD946, WD948–WD950, WP514. No. 103 Sqn: WD949, WD995, WD999. No. 139 Sqn: WD951. No. 245 Sqn: WD955, WE113, WE122. No. 360 Sqn: WD935, WD955, WF890, WF916. No. 617 Sqn: WD961, WD964, WD965, WD980, WD982, WD984, WD986, WD995, WF891. 228 OCU: XA536. 231 OCU: WD934, WD938, WD950, WD951, WD953, WD957, WD966, WD981, WD986, WD987, WE113–WE122, WF886–WF890, WF892, WF908, WF910–WF913. RAFFC/CAW: WD966, WE112, WP515. ETPS: WE121. CFS: WD944, WE112. Crashed aircraft: WD991 w/o 25 March, 1952, before delivery, replaced by XA536. To civil register: WD937, registered G-ATZW 5 October, 1966. Converted to T.4: WD954, WE111, WE118. Converted to U.10 and U.14: WD929, WD941, WD951, WD961. Converted to T.11 and T.19: XA536. Converted to T.17: WD955, WF890, WF916. Used for research and development: WD929, WD931, WF917, WG788, WG789 (TRE and RRE): WD929, WD931, WD945, WD947, WD953. WD954, WD962, (RAE); WD930, WD943, WD959, WF909 (Avon test-beds, R-R); WD933, WV787 (Sapphire test-beds, Armstrong Siddeley); WD952 (Olympus test-bed, Bristol Siddeley); WF909 (Gyron Junior test-bed, de Havilland); WD937/G-ATZW, WD956, WD958 (development work, EE); WD945 (A & AEE); WD947, WD953, WV787 (radar development, Ferranti); WD954, WD956, WD992 (guided missile development); WV787 (water spray gear for engine de-icing trials). Loaned to No.75 Sqn RNZAF: WD948, WD963, WF915. To USA: WD932, WD940, replacements for RAF were WG788, WG789. To Australia: WD939, WD983, replacements for RAF were WP514, WP515. Loaned to RAAF: WD935, WD942. Preserved: WD935 (RAF St Athan Museum), WV787 (Newark Air Museum). PR.3 aircraft: No.39 Sqn: WE135, WE137–WE139, WE144, WE145, WE148, WE168, WE169, WE173–WE175, WF922, WF924, WF926, WF927. No.69 Sqn: WE137–WE140, WE142, WE144, WE148, WE168, WE169, WE174, WE175, WF922, WF924, WF926. No.540 Sqn: WE136, WE137, WE139–WE142, WE144, WE150, WF923. No. 542 Sqn: WE136, WE140, WE142, WE150, WE151, WE166, WE167, WE170. 231 OCU: WE135–WE137, WE139–WE144, WE150, WE151, WE166–WE175, WF923–WF925, WF927. A & AEE: WF922. RRE: WE147. RAE: WE146, WE173. To RAF Museum: WE139, winner of London-New Zealand air

race, 1953. Modified aircraft: WE146, converted as Short SD.1 to carry two Beech AQM-37A high-speed target missiles. Operated by RAE at Llanbedr. Preserved: WE168 (Manston), WF922 (Midland Aircraft Museum, Coventry). T.4 aircraft: No. 56 Sqn: WE188. No. 58 Sqn: WE194, WE195. No. 85 Sqn: WE193. No. 542 Sqn: WE192, WE194. 231 OCU: WE188, WE191, WE192, WE195. Blind Landing Experimental Unit: WE189. To New Zealand: WE190 (after conversion to T.13).

English Electric Canberra B.2, PR.3, T.4, B.6 and PR.7: Contract No. 6/ACFT/5786/CB6(b), received November 1950, for 215 aircraft, ordered as B.2, PR.3 and T.4, but built as 112 B.2, WH637–WH674, WH695–WH742, WJ712–WJ734, WJ751–WJ753: One PR.3, WH772; 37 T.4, WH839–WH850, WJ857–WJ881; 31 B.6, WJ754–WJ784; 34 PR.7, WH773–WH780, WH790–WH804, WJ815–WJ825. Nine B.6 added as replacements, WT304–WT306, WT369–WT374. B.2 first flights 26 August, 1952 to 30 December, 1953; PR.3 first flight 29 January, 1954; T.4 first flights 24 February, 1954 to 18 February, 1955; B.6 first flights 26 January, 1954 to 5 May, 1955. PR.7 first flights 16 August, 1953 to 27 September, 1954. B.2 aircraft: No. 7 Sqn: WJ715, WJ721. No. 9 Sqn: WH637, WH706, WH729, WH742, WJ716, WJ728. No. 10 Sqn: WH640, WH646, WH653, WH665–WH668, WH672, WH674, WH718. No. 12 Sqn: WH647, WH649, WH659, WH662, WH732. No. 15 Sqn: WH713, WH724, WH725, WH731. No. 18 Sqn: WH740, WJ728, WJ733, WJ751, WJ753. No. 21 Sqn: WH695, WH701, WH723, WH729, WH732, WH742. No. 27 Sqn: WH723, WH728–WH730, WH732, WH733, WJ732. No. 35 Sqn: WH637, WH639, WH719, WJ732, WJ752. No. 44 Sqn: WH667, WH707, WH712, WH714, WH717–WH719, WH725. No. 45 Sqn: WH645, WH646, WH648, WH651, WH666, WH667, WH706, WH727, WH739, WH740. No. 50 Sqn: WH640–WH648, WH653, WH654, WH702, WH723, WH725, WH727, WH728, WH731, WH732, WJ717, WJ721, WJ723, WJ731. No. 51 Sqn: WH698, WH711. No. 56 Sqn: WH666. No. 57 Sqn: WH655, WH667, WH712, WH717, WH719, WH720, WH730, WH733. No. 61 Sqn: WH728, WJ724, WJ728, WJ732, WJ751, WJ753. No. 73 Sqn: WH638, WH647, WH649, WH741. No. 81 Sqn: WH651, WH706. No. 85 Sqn: WH641, WH667, WH703, WH714, WH724, WJ714, WJ753. No. 90 Sqn: WH643, WH654, WH659, WH705, WJ731. No. 97 Sqn: WH642, WH739. No. 98 Sqn: WH670, WH739, WJ722. No. 109 Sqn: WH640, WH644, WH645, WH650, WH658, WJ714. No. 115 Sqn: WH705, WJ751–WJ753. No. 139 Sqn: WH649, WH651, WH655, WH658, WH659, WH665, WH669, WH705, WH741. No. 149 Sqn: WH711, WH712, WH720, WH723, WH724. No. 199 Sqn: WH640, WH695. No. 245 Sqn: WH642, WH670, WH740, WJ751. No. 249 Sqn: WH638, WH647, WH650, WH654, WH655. No. 360 Sqn: WH646, WH664, WH665, WH740. 228 OCU: WH714, WH724. 231 OCU: WH641, WH642, WH648, WH657, WH664, WH703, WH704, WH715, WH716, WH727, WJ714, WJ728, WJ731. No. 728 Sqn (Royal Navy): WH704, WH720. RAFFC/CAW: WH638, WH639, WH673, WH699 *Aries IV*. ETPS: WH715, WJ730. Fleet Requirements Unit: WJ717. Converted to T.4: WH637, WH651, WH659, WH706. Converted to U.10 and U.14: WH652, WH704, WH705, WH710, WH720, WH729, WH733, WH742. Converted to T.11 and T.19: WH714, WH724. Converted to T.17: WH646, WH664, WH665, WH740. Converted to TT.18: WH718, WJ715, WJ717, WJ721.

Used for research and development: WH657, WH738 (RAE); WH660, WH702 (RRE); WH661, (parachute mine trials); WH671 (Avon test-bed, R-R); WH700, WH735 (guided missile development); WH713 (Olympus test-bed, Bristol Siddeley); WH734 (flight refuelling trials). Loaned to No. 75 Sqn RNZAF: WH645, WH646, WH666, WH739, WH740, WJ715. Loaned to RAAF: WH710. To Rhodesia: WH644, WH653, WH658, WH662, WH672, WH674, WH707. To Venezuela: WH708, WH709, WH721, WH722, WH736, WH737, replacements for RAF were B.6s WT369–WT374. Preserved: WH725 (Imperial War Museum, Duxford). PR.3 aircraft: 231 OCU: WH772. T.4 aircraft: No. 3 Sqn: WH846. No. 13 Sqn: WJ872. No. 14 Sqn: WH850. No. 15 Sqn: WH850. No. 16 Sqn: WH843, WJ868, WJ880. No. 39 Sqn: WJ861, WJ876. No. 51 Sqn: WH845, WJ873, WJ877, WJ879. No. 58 Sqn: WJ877, WJ879. No. 85 Sqn: WH849, WJ861. No. 88 Sqn: WH842, WH850. No. 97 Sqn: WH839, WH840, WH845, WH849. No. 98 Sqn: WJ860. No. 151 Sqn: WH839, WH840, WJ862. No. 360 Sqn: WH839, WJ862. 231 OCU: WH839–WH849, WJ857, WJ861, WJ869–WJ871, WJ874, WJ875. RAFFC/CAW: WH848. ETPS: WJ867. Marham Station Flight: WH848, WH849, WJ861, WJ865. Brüggen Station Flight: WH840–WH842, WJ870. Laarbruch Station Flight: WH842, WH843. Wildenrath Station Flight: WH850. Akrotiri Instrument Training Flight: WJ872, WJ881. Used for research: WH844 (RAE); WJ865 (A & AEE). Preserved: WH840 (Locking). B.6 aircraft: No. 6 Sqn: WJ762, WJ771, WJ776–WJ778, WJ780, WT369, WT372, WT373. No. 9 Sqn: WJ756, WJ759, WJ761, WJ766, WJ781. No. 12 Sqn: WJ754, WJ758, WJ760, WJ762, WJ764. No. 45 Sqn: WJ766, WT370. No. 51 Sqn: WJ768, WJ775, WT305 (these aircraft had radar equipment in lengthened noses). No. 73 Sqn: WJ760, WJ762, WJ764. No. 76 Sqn: WJ754, WJ757, WJ777. No. 101 Sqn: WJ754, WJ756, WJ758–WJ762, WJ764, WJ766, WJ768. No. 109 Sqn: WJ767, WJ768, WJ771, WJ772, WJ780. No. 139 Sqn: WJ767–WJ769, WJ772–WJ774, WJ776–WJ778, WJ780–WJ783, WT304, WT306, WT369–WT373. No. 249 Sqn: WJ770, WJ774, WJ777, WJ781–WJ783, WT369, WT370, WT374. No. 617 Sqn: WJ773, WJ774, WJ776, WT369, WT370, WT372. Akrotiri Strike Wing (B.15s and B.16s of Nos. 6, 32, 73, 249 Sqns operating in pool): WJ756, WJ760, WJ762, WJ764, WJ773, WJ774, WJ776–WJ778, WJ780–WJ783, WT306, WT369, WT373, WT374. Converted to B.15: WJ756, WJ760, WJ762, WJ764, WJ766. Converted to B16:WJ770, WJ771, WJ773, WJ776–WJ778, WJ780–WJ783, WT306, WT369, WT370, WT372–WT374. Used for research: WJ755 (test-bed for Spectre rocket motor). To France: WJ763, WJ779, WJ784, replcements for RAF were WT304–WT306. PR.7 aircraft: No. 13 Sqn: WH778, WH796, WH799, WH801, WJ819. No. 17 Sqn: WH775, WH792, WH798, WH801–WH804, WJ817, WJ823. No. 31 Sqn: WH773, WH775, WH779, WH792, WH798, WH800, WH801, WJ816. No. 58 Sqn: WH773, WH790, WH791, WH794–WH796, WH799–WH804, WJ815–WJ825. No. 80 Sqn: WH779, WH797, WH800, WJ817. No. 81 Sqn: WH777, WH778, WH780, WH791, WH795, WJ822. No. 82 Sqn: WH773, WH779, WH790, WH799, WJ818. No. 199 Sqn: WH796. No. 540 Sqn: WH773 (Air Race flight), WH790, WH791, WH795, WH800, WH801. No. 542 Sqn: WH779, WH790, WH791, WH795, WH796, WH799. RRE: WH774, WH776. RAE: WH776. Converted to PR.9

prototype: WH793. Converted to T.22: WH780, WH797, WH801, WH803. Preserved: WH773 (Wyton), WH791 (Cottesmore), WH798 (Wales Aircraft Museum, Rhoose), WJ821 (Bassingbourn).

English Electric Canberra T.4, B.6, B(I)6, PR.7 and B(I)8: Contract No. 6/ACFT/6445/CB6(b), received early 1951, for 190 aircraft. Ordered as B.2, T.4 and PR.7. B.2s WT301–WT348, WT362–WT387, WT397–WT422, WT440-WT469, totalling 130 aircraft: of which 61 were built as B.6, B(I)6, and B(I)8 and remainder were cancelled. The aircraft built comprised 12 B.6, WT301–WT306, WT369–WT374; 19 B(I)6, WT307–WT325; 30 B(I)8, WT326–WT348, WT362–WT368. Remaining 58 aircraft built under this contract were 18 T.4, WT475–WT492, and 40 PR.7, WT503–WT542. Further amendments to contract: nine B.6, WT304–WT306, WT369–WT374 transferred to second contract (see preceding contract for details); three B(I)6, XG554, XJ249, XJ257 added; five B(I)8, XK951–XK953, XM244, XM245 added as replacements. Manufacture of seven B(I)8, (WT337, WT340, WT342, WT345, WT347, WT363, WT366), transferred to Short Bros & Harland under direct sub-contract from English Electric, but Service details for these aircraft are included here. T.4 first flights 26 February, 1955 to 28 September, 1955; B.6 first flights 9 November, 1954 to 24 November, 1954; B(I)6 first flights 31 March, 1955 to 24 April, 1956; PR.7 first flights 1 October, 1954 to 19 March, 1956; B(I)8 first flights 8 June, 1955 to 11 August, 1958. T.4 aircraft: No. 14 Sqn: WT486. No. 16 Sqn: WT483. No. 17 Sqn: WT482, WT487. No. 39 Sqn: WT478, WT481. No.85 Sqn: WT485. No. 88 Sqn: WT479, WT486, WT488. No. 98 Sqn: WT488. No. 245 Sqn: WT488. 230 OCU: WT476. 231 OCU: WT475, WT476, WT478–WT840, WT482, WT483, WT485–WT487, WT489, WT490. CFS: WT480. Loaned to RNZAF: WT480. To Australia: WT491, WT492.

B.6 aircraft: No. 12 Sqn: WT303. No. 51 Sqn: WT301, WT305. No. 139 Sqn: WT302, WT303. No. 249 Sqn: WT303. Akrotiri Strike Wing: WT302, WT303. Converted to B.16: WT302, WT303. Preserved: WT305 (Wyton).

B(I)6 aircraft: No. 213 Sqn: WT307, WT310–WT325, XG554, XJ249, XJ257. RAE: WT308, WT309. A & AEE: WT307.

PR.7 aircraft: No. 13 Sqn: WT508, WT527, WT530, WT540. No. 17 Sqn: WT506, WT507, WT509, WT510, WT513, WT520, WT523, WT525, WT532–WT538. No. 31 Sqn. WT507, WT510, WT511, WT513–WT519, WT521, WT523, WT524, WT527, WT531–WT533, WT537, WT538, WT540. No. 58 Sqn: WT503–WT507, WT509, WT512–WT514, WT530, WT532. No. 80 Sqn: WT509, WT514, WT516–WT522, WT524–WT527, WT530, WT531, WT536, WT538. No. 81 Sqn: WT523. RAFFC: WT528 *Aries V*. CFE: WT529. To India: WT539, WT541, WT542. Converted to T.22: WT510, WT525, WT535. Preserved: WT537 (BAe Samlesbury).

B(I)8 aircraft: No. 3 Sqn: WT330, WT332, WT336, WT345, WT347, WT363, WT364, WT366, XK952, XM244. No. 14 Sqn: WT336, WT337, WT339, WT345–WT347, WT362, WT363, WT365, WT366, WT368, XK951, XM245. No. 16 Sqn: WT332, WT334, WT337, WT340–WT342, WT344, WT347, WT362, WT368, XK951, XK952, XM244, XM245. No. 59 Sqn: WT330, WT345, WT363, WT366, XK952, XM244. No. 88 Sqn: WT329–WT333, WT335–WT337, WT339, WT340, WT342, WT344, WT346, WT362, WT365, WT368, XK951. No. 100 Sqn: WT347 (used for trials work). RRE: WT327, WT333. A & AEE: WT326, WT328. Used for

research: WT327 (radar research with Ferranti). To Peru: WT343, WT348, WT367, replacements for RAF were XK951–XK953. To India: WT338 (TI aircraft for B(I)58), XK953, replacements for RAF were XM244, XM245. To New Zealand: WT329, replacement for RAF was XM936 (ordered under eighth contract). Preserved: WT346 (Cosford Museum).

English Electric Canberra B(I)8 and PR.9: Contract No. 6/ACFT/11158/CB6(b), received 1954, for 57 aircraft, comprising 32 PR.9, XH129–XH137, XH164–XH186; 25 B(I)8, XH203–XH209, XH227-XH244. All PR.9s transferred to Short Bros & Harland under MoS contract; manufacture of five B(I)8 (XH204, XH208, XH228, XH231, XH234) transferred to Short Bros & Harland under direct sub-contract from English Electric. (PR.9-Service details are included under Short Bros & Harland contract details). Nineteen B(I)8 added, XK959, XM262–XM279, as replacements for aircraft exported. B(I)8 first flights 11 September, 1956 to 28 February, 1959.

B(I)8 aircraft: No.3 Sqn: XH204, XH207, XH208, XH228, XH231, XM266, XM267, XM271, XM273, XM275, XM276, XM279. No. 14 Sqn: XM264, XM269, XM277, XM278. No. 16 Sqn: XH209, XH231, XH234, XM262, XM263, XM265, XM267–XM270, XM272, XM274, XM275, XM277–XM279. No. 59 Sqn: XH204, XH207–XH209, XH228, XH231, XH234, XM266. No. 88 Sqn: XM269, XM270, XM272. To Peru: XH206, replacement for RAF was XK959. To India: XH203, XH205, XH227, XH229, XH230, XH232, XH233, XH235–XH243, XK959, replacements for RAF were XM262–XM278. To Venezuela: XH244, replacement for RAF was XM279.

English Electric Canberra T.4 and B.6: Contract No. 6/ACFT/11313/CB6(b), received 1954, for six aircraft, comprising two T.4, XH583, XH584; four B.6, XH567–XH570. T.4 first flights 1 February, 1955 and 1 March, 1955; B.6 first flights 19 January, 1955 to 21 March, 1955. T.4 aircraft: 231 OCU: XH583, XH584. 232 OCU: XH583. B.6 aircraft: No.139 Sqn: XH570. Akrotiri Strike Wing: XH570. Converted to B.16: XH570. Used for research: XH567, XH568 (radar research, RRE); XH568 (low-level gust research, RAE); XH567, XH568 (torpedo development).

English Electric Canberra PR.9: Contract No. 6/ACFT/12164/CB6(b) received 1955 for 11 PR.9 aircraft, XK440–XK443, XK467–XK473. All transferred to Short Bros & Harland under MoS contract.

English Electric Canberra T.4 and B.6: Contract No. 6/ACFT/12265/CB6(b), received 1955, for three aircraft, comprising two T.4, XK647, XK650, and one B.6, XK641. B.6 first flight 3 May, 1956. T.4 aircraft: To India: XK647, XK650; replacements for RAF were ordered, (XM228, XM229), but later cancelled. B.6 aircraft: No. 12 Sqn: XK641. No. 45 Sqn: XK641. Converted to B.15: XK641.

English Electric Canberra B(I)8, B(I)12 and T.13: Contract No. KD/E/01/CB6(b), received early 1958 for 12 aircraft, comprising one B(I)8, XM936; nine B(I)12; two T.13. The B(I)12 and T.13 aircraft ordered on behalf of New Zealand. (For further details see overseas orders–New Zealand.) The first B(I)12 was a modified RAF B(I)8, WT329, XM936 was ordered to replace WT329. The second T.13 was a modified RAF T.4, WE190; no replacement for WE190. XM936 first flight 17 March, 1959, service with No. 3 Sqn.

English Electric Canberra B(I)12: Contract No. KC/2R/08/CB9(c), received early 1960 for two B(I)12 aircraft, ordered on behalf of New Zealand. (For further details see overseas orders–New Zealand.)

English Electric Canberra overseas orders (customers in chronological order):

Australia–one contract received 1951. Two B.2 aircraft diverted from first British production contract as pattern aircraft for Australian production. First aircraft, WD939, delivered August, 1951, to A84-307; second, WD983, delivered May, 1952, to A84-125. Both converted to T.21 about 1958–60.

Australia–ex RAF aircraft in 1956. Two T.4 aircraft, WT491 and WT492, which became A84-501 and A84-502.

USA–one contract, received 1951. Two B.2 aircraft, diverted from first British contract for evaluation and use as pattern aircraft for United States production. First aircraft, WD932, delivered February, 1951, to 51-17387, not used. Crashed 21 December, 1951. Second aircraft, WD940, delivered September, 1951, to 51–17352.

Venezuela–first contract, received January, 1953. Six new B.2 aircraft, diverted from second British production contract. 1A-39 (ex-WH708), 2A-39 (ex-WH709), 3A-39 (ex-WH721), 1B-39 (ex-WH722), 2B-39 (ex-WH736), 3B-39 (ex-WH737). Delivered March-July, 1953. Service with 39th Bomber Sqn of Venezuelan Air Force.

Venezuela–second contract, received February, 1957. Ten new aircraft; comprising eight B(I)8, 4A-39, 5A-39, 4B-39, 5B-39, 1C-39, 2C-39, 3C-39, 4C-39; and two T.4, 1E-39, 2E-39. 4A-39 (the last was diverted from fourth British production contract, ex-XH244). B(I)8s delivered June, 1957 to January, 1958, T.4s delivered December, 1957 and February, 1958. Service with 39th Bomber Sqn.

Venezuela–third contract, received 1964. Fourteen refurbished aircraft; comprising 12 B.2, 0129 (ex-WH877), 1131 (ex-WH647), 1183 (ex-WJ570), 1233 (ex-WF914), 1280 (ex-WH881), 1339 (ex-WH649), 1364 (ex-WD993), 1425 (ex-WH712), 1437 (ex-WH730), 1511 (ex-WH862), 1529 (ex-WH732), 2001 (ex-WJ980); and two PR.3, 2314 (ex-WE172), 2444 (ex-WE171). B.2s delivered December, 1965 to April, 1967, T.4s delivered August, 1966 and October ,1966. 1529 used Class B registration G27-3 before delivery. Service with 40th Bomber Sqn.

France–one contract, received early 1954. Six new aircraft; comprising four B.6, (first three diverted from second British production contract), F763 (ex-WJ763), F779 (ex-WJ779), F784 (ex-WJ784), F304; and two B(I)6, F316, F318. First three delivered August, 1954 to January, 1955, second three delivered August-December, 1955. All used for research. Some years after delivery F779 was fitted with Mk 8 type front fuselage and used as radar test-bed. Preserved: F763 (Musée de l'Air, Le Bourget).

Ecuador–one contract, received May, 1954. Six new B.6 aircraft, E801-E806. Delivered two at a time in April, June, July, 1955.

Peru–first contract, received November, 1955. Eight new B(I)8 aircraft, (first four diverted from British contracts), 474 (ex-WT343), 475 (ex-WT348), 476 (ex-WT367), 478 (ex-XH206), 479–482. (Serial No. 477 not used). Delivered May, 1956 to March, 1957. Service with a squadron of Groupo 21, Peruvian Air Force. Several years after delivery six aircraft remaining in service were renumbered: 474 to 206, 475 to 207, 478 to 209, 480 to 210, 481 to 211, 482 to 212.

Peru–second contract, received 1959. One new B(I)8 aircraft, ordered as a replacement for 476 which had crashed. When Peruvian aircraft were renumbered the replacement became 208, delivered as 208 November, 1960.

Peru–third contract, received 1965. Eight refurbished aircraft; comprising six B.2, 233 (ex-WJ974), 234 (ex-WJ976), 235 (ex-WK112), 236 (ex-WH726), 237 (ex-WH868), 238 (ex-WE120); and two T.4, 231 (ex-WH659), 232 (ex-WJ860). B.2s delivered August, 1966 to December, 1967. 233 was delivered after the other B.2s, and used Class B registration G27–76 during trials work before delivery. T.4s delivered April and May, 1966. Service with the second Canberra squadron of Groupo 21, Peruvian Air Force.

Peru–fourth contract, received 1967. Six refurbished aircraft designated B(I)56; 239 (ex-WT208), 240 (ex-WJ757), 241 (ex-WJ754), 242 (ex-WH880), 243 (ex-WJ712), 244 (ex-WH719). Registered G27–96 to G27-101 for test flying before delivery, delivered February-June, 1969.

Peru–fifth contract, received 1969. One refurbished aircraft designated B(I)68; 245 (ex-WT344). Registered G27-145 for test flying before delivery, delivered July, 1971.

Peru–sixth contract, received about 1971. One refurbished T.4 aircraft, 246. Registered G27-224 for test flying before delivery, delivered February, 1973. (Previously WH845 and India Q496).

Peru–seventh contract, placed June, 1973 with Marshalls of Cambridge. Eight (later eleven) ex-RAF B(I)8; 247 (ex-WT368), 248 (ex-XK951), 249 (ex-WT342), 250 (ex-WT364), 251 (ex-WT340), 252 (ex-XH234), 253 (ex-XM273), 254 (ex-XM936), 255 (ex-XM263), 256 (ex-XM276), 257 (ex-XM278). Delivered March, 1975–July, 1978.

India–first contract, received January, 1957. 68 new aircraft; comprising six T.4s, IQ994–IQ999; eight PR.57s, IP986–IP993; 54 B(I)58s, IF895–IF934, IF960–IF973. Also an option on 12 further new aircraft, taken up July, 1957, comprising 11 B(I)58s, IF974–IF984, and one T.4, IQ985. Contract total thus became 80 aircraft, comprising seven T.4s, eight PR.57s and 65 B(I)58s. Twenty-four aircraft were diverted from British contracts, as follows: IQ994 (ex-XK647), IQ995 (ex-XK650), IP986 (ex-WT539), IP987 (ex-WT542), IP988 (ex-WT541), IF895 (ex-XK953), IF896 (ex-XH203), IF897 (ex-XH205), IF898 (ex-XK959), IF899 (ex-XH227), IF900 (ex-XH229), IF901 (ex-XH230), IF902 (ex-XH232), IF903 (ex-XH233), IF904 (ex-XH235), IF905 (ex-XH236), IF906 (ex-WT338), IF907–IF913 (ex-XH237–XH243). Deliveries April, 1957 to September, 1959. Service with Nos. 5, 16, 35 Sqn IAF (B(I)58s); No. 106 Sqn IAF (PR.57s); Jet Training Wing (T.4s).

India–second contract, received 1961. Six new B(I)58 aircraft; BF595–BF600. Delivered in 1963.

India–third contract, received later 1962. Three ex-RAF aircraft, comprising one T.4, BQ744 (ex-WJ859), and two PR.57s BP745 (ex-WT506) and BP746 (ex-WT528). Delivered late 1963–early 1964.

India–fourth contract, received 1965. Three ex-RAF T.4 aircraft, Q495 (ex-WH847), Q496 (ex-WH845), Q497 (ex-WE191). Delivery embargoed in 1966, all three aircraft to RAF Kemble for storage. Mid-1968 Q495 to

BAC Samlesbury, prepared for delivery (test flying as G27-116), delivered to India July, 1968. Q496 and Q497 never delivered to India. (Q496 bought by BAC and sold to Peru; Q497 bought by BAC, stored at Samlesbury, still present 1987.)

India–fifth contract, received 1969. 12 refurbished aircraft comprising ten B(I)66 and two PR.67. B(I)66: IF1020 (ex-WT210/G27-168), IF1021 (ex-WH954/G27-167), IF1022 (ex-WH959/G27-177), IF1023 (ex-WH961/G27-178), F1024 (ex-WT303/G27-170), F1025 (ex-WJ780/G27174), F1026 (ex-WT302/G27-172), F1027 (ex-WT373/G27-173), F1028 (ex-WJ776/G27-171), F1029 (ex-WJ778/G27-169); PR.67: P1098 (ex-WH800/G27-183), P1099 (ex-WJ816/G27-184). Delivered between October, 1970 and August, 1971.

India–sixth contract, 1975, for six ex-RAF T.4s, bought direct from the RAF. From storage at RAF Kemble, Q1791 (ex-WE193), Q1792 (ex-WE195), Q1793 (ex-WT485), Q1794 (ex-WT487), Q1795 (ex-WH839), Q1796 (ex-WJ868). Delivered June-September, 1975.

Rhodesia–order placed late 1957, for 15 ex-RAF B.2 aircraft. Order met from RAF stocks of B.2s, aircraft not handled by English Electric. Aircraft were RRAF 159–RRAF 173 (ex-WH867, WH653, WH662, WH672, WH707, WH855, WH871, WH883, WJ571, WJ572, WJ578, WJ606, WK108, WJ612, WH644 respectively). Delivered March-June, 1959. Service with Nos. 5 and 6 Sqns RRAF. A few years after delivery renumbered RRAF 200–214. In 1970, B.2s again renumbered, *eg* 2005, 2051, 2085, 2502, 2510, 2514. (The squadron number 5 was combined with the original three-figure serial numbers).

Rhodesia–one contract to English Electric, received about 1958. Three ex-RAF T.4 aircraft, RRAF 174 (ex-WH658), RRAF 175 (ex-WH674), RRAF 176 (ex-WJ613). Aircraft to English Electric as B.2s, modified to T.4s before delivery in spring 1961. Later renumbered RRAF 215–217. In 1970 again renumbered, *eg* 2155, 2175.

Zimbabwe–two ex-RAF aircraft supplied direct from the RAF. B.2 2250 (ex-WH666) and T.4 2215 (ex-WJ869). Both left RAF Marham on delivery 25 March, 1981.

New Zealand–first contract, received early 1958, through British MoS. (See eighth British production contract.) Eleven aircraft; comprising nine B(I)12, NZ6101 (ex-WT329), NZ6102 to NZ6109; two T.13, NZ6151, NZ6152 (ex-WE190). Delivered September, 1959 to February, 1960 (B(I)12), and late 1960 (T.13). Service with 14 Sqn RNZAF. In 1970 ZN6106 sold to BAC, and six B(I)12s (NZ6102, NZ6103, NZ6105, NZ6107–NZ6111) and two T.13s (NZ6151 and NZ6152) sold to India.

New Zealand–second contract, received early 1960, through British MoS. (See ninth British production contract.) Two B(I)12 aircraft; NZ6110, NZ6111. Delivered March and April, 1961. Service with 14 Sqn RNZAF. Both aircraft sold to India in 1970.

Sweden–one contract, received late 1959. Two modified ex-RAF B.2 aircraft; 52001 (ex-WH711), 52002 (ex-WH905). Aircraft modified by Boulton Paul, Swedish designation Tp52. Delivered in 1960, used for research work. Preserved: By 1979 both aircraft were in museums.

South Africa–first contract, received 1961. Six new B(I)12 aircraft, 451–456. Delivered late 1963–early 1964. Service with 12 Sqn SAAF.

South Africa–second contract, received early 1963. Three ex-RAF T.4 aircraft, 457 (ex-WJ617), 458 (ex-WJ864), 459 (ex-WJ991). Delivered early 1964. Service with 12 Sqn SAAF.

German Federal Republic–one contract, received 1965. Three ex-RAF B.2 aircraft, YA151 (ex-WK130), YA152 (ex-WK137), YA153 (ex-WK138). Delivered September and December, 1966. Service with Erprobungstelle 61 at Oberpfaffenhofen for experimental work. In 1968 renumbered 0001, 0002, 0003; in 1970 two aircraft to Mil Geo Amt for photographic-survey work, 0002 became D9566, 0003 became D9567. In 1971 0001 transferred to DFVLR, became D9569. In 1976 D9500 series registrations changed to 9900 series; D9566 became 9934, D9567 became 9935 and D9569 became 9936. Preserved: 9936 at Sinsheim Museum.

Ethiopia—one contract, received 1967. Four refurbished aircraft designated B.52; 351 (ex-WH638), 352 (ex-WK104), 353 (ex-WJ971), 354 (ex-WD990). Registered G27-117 to G27-120 for test flying before delivery in July-November, 1968

Argentina–first contract, received late 1967. Twelve refurbished aircraft; comprising ten B.62, B101 to B110; two T.64, B111 and B112. B.62: B101 (ex-WJ616/G27-111), B102 (ex-WJ713/G27-112), B103 (ex-WJ714/G27-113), B104 (ex-WH913/G27-114), B105 (ex-WH702/G27-127), B106 (ex-WJ609/G27-165), B107 (ex-WH727/G27-162), B108 (ex-WH886/G27-164), B109 (ex-WH875/G27-163), B110 (ex-WJ619/G27-166). T.64: B111 (ex-WT476/G27-121), B112 (ex-WJ875/G27-122). Deliveries in batches of three in November, 1970, February, May and September, 1971. (For the purpose of appearing at the 1970 Farnborough Air Show B101 registered G-AYHO and B102 registered G-AYHP on 22 July, 1970.)

Argentina–second contract, received mid-1981. Two aircraft, one B.92 (ex-WH914/G27-373) and one T.94 (ex-XH583/G27-374). Contract suspended 1982, aircraft into storage at Samlesbury, still present 1987.

Chile–three ex-RAF aircraft supplied direct from the RAF. PR.9s, 341 (ex-XH166), 342 (ex-XH167), 343 (ex-XH173). All three left RAF Wyton 15 October, 1982, on delivery.

Production of English Electric Canberras in United Kingdom by A.V. Roe, Handley Page, and Short Bros & Harland:

A.V. Roe–first contract No. 6/ACFT/5990/CB6(b), received November, 1950. One hundred B.2 aircraft, WJ971–WJ995, WK102–WK146, WK161–190. (Last 25 aircraft, WK166–WK190 cancelled.) First aircraft flown 25 November, 1952, deliveries March, 1953 to March, 1955. No. 6 Sqn: WJ972, WJ973, WJ993, WK109. No. 7 Sqn: WK118, WK122, WK124, WK127. No. 9 Sqn: WJ976, WJ977, WJ994, WK109, WK126. No. 12 Sqn: WJ976, WJ994, WK107, WK110. No. 32 Sqn: WJ972, WK111, WK115. No. 35 Sqn: WJ975, WK114, WK125, WK130, WK133. No. 57 Sqn: WJ972, WJ977, WJ986, WK131. No. 73 Sqn: WK103, WK104, WK111, WK117. No. 85 Sqn: WJ975, WK106, WK116. No. 90 Sqn: WJ986, WJ993, WJ995, WK103, WK105, WK115. No. 98 Sqn: WK130, WK133, WK144, WK145, WK162. No. 100 Sqn: WK123, WK126 (trials work). No. 102 Sqn: WK137, WK138, WK146. No. 103 Sqn: WJ981, WK108, WK118, WK119, WK124. No. 115 Sqn: WJ986, WJ994, WK104, WK110, WK140. No. 139 Sqn: WJ971, WJ977, WJ980. No. 207 Sqn: WJ978, WJ993, WK102, WK117, WK142. No. 245 Sqn: WK144, WK145, WK162. No. 360 Sqn: WJ984, WJ986, WJ988, WK102, WK111. ETPS: WJ994. CFS: WJ991. Fleet Requirements Unit: WK123, WK126, WK142.

Converted to U.10: WJ987, WK107, WK110. Converted to T.11 and T.19: WJ975, WK106. Converted to T.17: WJ977, WJ981, WJ986, WJ988, WK102, WK111. Converted to TT.18: WK118, WK122–WK124, WK126, WK127, WK142. Used for research and development: WJ990, WJ992, WK120, WK128, WK163, WK164 (RRE); WJ995, WK135 (RAE); WK121, WK164 (A & AEE); WK141 (Sapphire and Viper test-bed, Bristol Siddeley); WK143 (flight refuelling and target-towing trials, Flight Refuelling Ltd); WK163 (Double Scorpion rocket test-bed, Napier; and Viper test-bed, Bristol Siddeley). Loaned to No. 75 Sqn RNZAF: WJ981, WJ986, WJ988, WK102. Preserved: WJ975 (Cleethorpes).

A.V. Roe–second contract No. 6/ACFT/6447/CB6(b), received April, 1951. Fifty B.2 aircraft, WT140–WT189. All cancelled.

Handley Page–first contract No. 6/ACFT/5943/CB6(b), received November, 1950. One hundred B.2 aircraft WJ564–WJ582, WJ603–WJ649, WJ674–WJ707. (Last 25 aircraft, WJ683–WJ707, cancelled). First aircraft flown 5 January, 1953; deliveries March, 1953 to May, 1955. No. 6 Sqn: WJ603, WJ614, WJ629. No. 7 Sqn: WJ566, WJ629. No. 9 Sqn: WJ604, WJ623, WJ631. No. 18 Sqn: WJ605, WJ616, WJ646. No. 21 Sqn: WJ573, WJ604, WJ609, WJ617. No. 35 Sqn: WJ603, WJ614, WJ634, WJ637, WJ642, WJ676. No. 45 Sqn: WJ567, WJ570, WJ576, WJ605, WJ632, WJ648. No. 50 Sqn: WJ615, WJ623, WJ635, WJ641, WJ675, WJ676. No. 51 Sqn: WJ768, WJ775. No. 57 Sqn: WJ574, WJ575, WJ612, WJ645. No. 85 Sqn: WJ567, WJ610, WJ620, WJ631, WJ640, WJ678. No. 98 Sqn: WJ603, WJ611, WJ614, WJ620, WJ681, WJ682. No. 149 Sqn: WJ564, WJ567, WJ612, WJ626, WJ627. No. 245 Sqn: WJ603, WJ611, WJ640, WJ676, WJ681. No. 360 Sqn: WJ576, WJ581, WJ616, WJ625, WJ630, WJ635. No. 728 Sqn (Royal Navy): WJ638. 228 OCU: WJ610, WJ617. 231 OCU: WJ568, WJ577, WJ581, WJ631, WJ637, WJ640, WJ641, WJ649, WJ674, WJ677. Fleet Requirements Unit: WJ636. Converted to T.4: WJ566, WJ568, WJ617. Converted to U.10 and U.14: WJ604, WJ621, WJ623, WJ624, WJ638. Converted to T.11 and T.19: WJ610. Converted to T.17: WJ565, WJ576, WJ581, WJ607, WJ625, WJ630, WJ633. Converted to TT.18: WJ574, WJ614, WJ629, WJ632, WJ636, WJ639, WJ680, WJ682, WJ715, WJ717, WJ721. Used for research and development: WJ627, WJ646, WJ679 (RRE); WJ638 (A & AEE); WJ643 (radar research, Ferranti); WJ644 (guided missile trials). Loaned to 75 Sqn RNZAF: WJ605, WJ630. To Rhodesia: WJ571, WJ572, WJ578, WJ606, WJ612, WJ613. Preserved: WJ573 (Henlow), WJ576 (Wales Aircraft Museum, Rhoose), WJ637 (Cranwell), WJ676 (Wroughton).

Handley Page–second contract No. 6/ACFT/6446/CB6(b), received April, 1951. Fifty B.2 aircraft, WS960–WS999, WT113–WT122. All cancelled.

Short Brothers & Harland–first contract, No. 6/ACFT/5790/CB6(b), received November, 1950. One hundred B.2 aircraft, built as 60 B.2, WH853–WH887, WH902–WH925, WH944; 40 B.6, WH945–WH984. First B.2 first flown 30 October, 1952, deliveries December, 1952 to August, 1954; B.6 deliveries November, 1954 to October, 1955. B.2 aircraft: No. 10 Sqn: WH853, WH856, WH867, WH870. No. 18 Sqn: WH866, WH919, WH925. No. 27 Sqn: WH859, WH861, WH917. No. 35 Sqn: WH909–WH911, WH916, WH918, WH944. No. 44 Sqn: WH856–WH858, WH867, WH871. No. 45 Sqn: WH853, WH874, WH922. No. 56 Sqn: WH861. No. 61 Sqn: WH908, WH914, WH915, WH918, WH922, WH924. No. 73 Sqn: WH858, WH870, WH880, WH886. No. 85 Sqn: WH878, WH903, WH904. No. 90 Sqn: WH854, WH870, WH880, WH905. No. 98 Sqn: WH869, WH911, WH913. No. 100 Sqn: WH913, WH914. No. 360 Sqn: WH863, WH874, WH902. No. 728 Sqn (Royal Navy): WH921. 228 OCU: WH903, WH904. 231 OCU: WH859, WH862, WH864, WH865, WH877, WH907, WH914, WH919, WH920, WH923, WH925, WH944. ETPS: WH854. Converted to T.4: WH854, WH861. Converted to U.10 and U.14: WH860, WH876, WH885, WH921. Converted to T.11 and T.19: WH903, WH904. Converted to T.17: WH863, WH872, WH874, WH902. Converted to TT.18: WH856, WH887. Used for research and development: WH854 (RAE); WH854, WH912 (radar research, RRE); WH876 (A & AEE). Loaned to 75 Sqn RNZAF: WH878, WH922. To Rhodesia: WH855, WH867, WH871, WH883. Preserved: WH904 (Newark Air Museum).

B.6 aircraft: No. 9 Sqn: WH951, WH954, WH955, WH960, WH961, WH964, WH969, WH972–WH974, WH977, WH980-WH984. No. 12 Sqn: WH947, WH948, WH951, WH954–WH956, WH958–WH960, WH963–WH965, WH967, WH968, WH970–WH972, WH974. No. 32 Sqn: WH947, WH955–WH957, WH966, WH968, WH970, WH972, WH984. No. 45 Sqn: WH958, WH961, WH963, WH965, WH969, WH977. No. 73 Sqn: WH954, WH964, WH974, WH977, WH981, WH982. No. 76 Sqn: WH946, WH959, WH962, WH976, WH979, WH980. No. 98 Sqn: WH972. No. 100 Sqn: WH945, WH977. No. 101 Sqn: WH945, WH948, WH951. No. 617 Sqn: WH946, WH950, WH955. Akrotiri Strike Wing (B.15s of Nos. 6, 32, 73, 249 Sqns operating in pool): WH947, WH948, WH955–WH957, WH959–WH961, WH964, WH966, WH970–WH973, WH981, WH983, WH984. Converted to B.15: WH947, WH948, WH954–WH961, WH963–WH974, WH977, WH981–WH984. Converted to E.15: WH948, WH957, WH964, WH972, WH973, WH981, WH983. Used for research and development: WH952 (RAE and A & AEE); WH953 (RRE). Preserved: WH952 (Woolwich).

Short Brothers & Harland–second contract, No. 6/ACFT/6448/CB6 (b), received April, 1951, for 50 B.6 aircraft, WT205–WT224, WT250–WT279. Only nine aircraft, WT205–WT213, built; remainder cancelled. Deliveries November, 1955 to April, 1956. No. 9 Sqn: WT205, WT209, WT213. No. 12 Sqn: WT209–WT211. No. 45 Sqn: WT208, WT209, WT211, WT213. No. 76 Sqn: WT206, WT207. Binbrook Station Flight: WT209, WT213. Converted to B.15: WT205, WT208–WT211, WT213. Used for research and development: WT205 (A & AEE); WT207 (Napier Double Scorpion rocket test-bed); WT208 (de Havilland Spectre rocket test-bed); WT212 (Institute of Aviation Medicine, part of RAE).

Short Bros & Harland–third contract, received April, 1955. Direct sub-contract from English Electric for manufacture of 12 B(I)8 aircraft; WT337, WT340, WT342, WT345, WT347, WT363, WT366, XH204, XH208, XH228, XH231, XH234. Delivered August, 1956 to May, 1957. For Service use see third and fourth British production contracts.

Short Bros & Harland–fourth contract, No. 6/ACFT/14027/CB6(b), received November, 1956. Forty-three PR.9 aircraft, XH129–XH137, XH164–XH186, XK440–XK443, XK467–XK473. (These aircraft

transferred to Shorts from fourth and sixth English Electric production contracts). In March, 1958 order reduced to 23 aircraft, XH129–XH137, XH164–XH177. Remainder cancelled. First aircraft flown 27 July, 1958; deliveries September, 1958 to December, 1960. No. 13 Sqn: XH130, XH131, XH133, XH135–XH137, XH164–XH167, XH169, XH172, XH173, XH177. No. 39 Sqn: XH131, XH134, XH137, XH164, XH167–XH176. No. 58 Sqn: XH133–XH137, XH164–XH177. No. 1 PRU: XH131, XH134, XH165, XH169, XH174, XH175. To Chile: XH166, XH167, XH173. Preserved: XH170 (Wyton). Used for development: XH132 (as Short SC.9 used for guided missile development).

Licensed production:

Government Aircraft Factory, Australia: forty-eight B.20 aircraft, A84-201 to A84-248. First aircraft flown 29 May, 1953, deliveries July, 1953 to December, 1958. Service with Nos. 1, 2 and 6 Sqns RAAF, also Canberra OCU, Aircraft Research and Development Unit. Converted to T.21: A84-201, A84-203 to A84-206.

Martin B-57, RB-57A and B-57B: First Martin contract–No. AF33(038)-22617, dated 3 September, 1953. Order received March, 1951 for 177 production aircraft, comprising eight B-57A, 52-1418 to 52-1425; 67 RB-57A, 52-1426 to 52-1492; 102 B-57B, 52-1493 to 52-1594. This contract also covered the two Canberra B.2s supplied from Britain, 51-17352 (ex-WD940) and 51-17387 (ex-WD932).

B-57A aircraft: all used for development work. To civil marks: 52-1418 as NASA218; 52-1419 as N1005.

RB-57A aircraft: Service with 10 TRW, 66 TRW, 363 TRW; 117 TRS (Kansas ANG), 154 TRS (Arkansas ANG), 165 TRS (Kentucky ANG), 172 TRS (Michigan ANG), 192 TRS (Nevada ANG). Converted to EB-57A: 52-1428, 52-1461, 52-1464, 52-1481, 52-1482, 52-1489. Rebuilt as RB-57F: 52-1427, 52-1432, 52-1433. To civil marks: 51-1438 as N96. Preserved: 52-1426, 52-1456, 52-1475, 52-1482, 52-485, 52-1488, 52-1492, 52-1499.

B-57B aircraft: Service with 345 BW (TAC), 461 BW (TAC), 3 BW (Pacific AF), 38 BW (TAC). 8 TBS and 13 TBS of 35 TFW in Vietnam; ANG units including 154 TRS, 165 TRS, 192 TRS (as RB-57B); DSES units including 4677 DSES, 4713 DSES, 4758 DSES (as EB-57B). To civil marks: 52-1576 as N637NA, later N809NA. Loaned to South Vietnam AF: 52-1532. Used as Bomarc test-bed: 52-1497. Converted to EB-57B: 51-1500, 52-1502, 52-1506, 52-1509, 52-1521 plus numerous others. Converted to MSB-57B: 52-1535, 52-1539. Converted to NB-7B: 52-1493, 52-1496, 52-1551, 52-1581. Converted to RB-57B; 52-1518, 52-1522, 52-1557, 52-1559, 52-1570, 52-1571, 52-1589. Rebuilt as RB-57F: 52-1527, 52-1536, 52-1539, 52-1559, 52-1562, 52-1573, 52-1574, 52-1583, 52-1594. Converted to B-57G: 52-1578, 52-1580, 52-1582, 52-1588. Preserved: 52-1500, 52-1504, 52-1505, 52-1509, 52-1516, 52-1519, 52-1526, 52-1548, 52-1551 (National Air and Space Museum, Washington D.C), 52-1584.

Martin B-57B, B-57C and RB-57D: Second Martin contract–No. AF33(600)-22208, dated 4 November, 1953. Order received October, 1952 for 191 aircraft, of which only 158 were eventually built. This total comprised 100 B-57B, 53-3859 to 53-935, 53-3937 to 53-3939, 53-3941 to

53-3943, 53-3945 to 53-3947, 53-3949 to 53-3962; 38 B-57C, 53-3825 to 53-3858, 53-3936, 53-3940, 53-3944, 53-3948; and 20 B-57D, 53-3963 to 53-3982. The remaining 33 aircraft (53-3983 to 53-4015) were cancelled. In 1955 the B-57Ds were transferred to the third contract as RB-57Ds.

B-57B aircraft: Service with 345 BW (TAC), 461 BW (TAC), 3 BW (Pacific AF), 38 BW (TAC). 8 TBS and 13 TBS of 35 TFW in Vietnam; several ANG units (as RB-57B); DSES units including, 4677 DSES, 4713 DSES, 4758 DSES (as EB-57B). To Pakistan Air Force: 53-3885, 53-3891, 53-3938, 53-3939, 53-3941 to 53-3943, 53-3945 to 53-3947, 53-3949 to 53-3952, 53-3954 to 53-3961. Converted to EB-57B: 53-3859 plus numerous others. Converted to RB-57B: 53-3860, 53-3920. Rebuilt as RB-57F: 53-3864, 53-3897, 53-3900, 53-3918, 53-3935. Converted to B-57G: 53-3860, 53-3865, 53-3877, 53-3878, 53-3886, 53-3889, 53-3898, 53-3905, 53-3906, 53-3928, 53-3929, 53-3931.

B-57C aircraft: Service with units operating B-57B; several ANG units, 117 TRS, 192 TRS (as RB-57C); several WRS, 55 WRS, 58 WRS (as RB-57C); 7407 CSW; 4416 TEWS (as RB-57C). To Pakistan Air Force: 53-3834, 53-3846, 53-3948. Converted to RB-57C: 53-3831, 53-3832, 53-3841, 53-3842, 53-3851, 53-3944. Converted to TB-57C: 53-3857. Preserved: 53-3841.

Martin RB-57D: Third Martin contract–No. AF33 (600)-25825. Order received 1955. Twenty RB-57D aircraft, 53-3963 to 53-3982. Service with various units attached to SAC, TAC, Pacific AF, Air Defense Command; 4677 DSES (as EB-57D). Converted to EB-57D: Nine aircraft, including 53-3964 to 53-3966, 53-3968, 53-3977, 53-3982. Rebuilt as RB-57F: 53-3970, 53-3972, 53-3974, 53-3975. Preserved: 53-3982 (Pima Air Museum, Arizona).

Martin B-57E: Fourth Martin contract–No. AF33(600)-29645, dated 4 January, 1956. Order received 1955 for 68 B-57E aircraft, 55-4234 to 55-4301. Service with Tow Target Squadrons, 1 TTS, 17 TTS; various ANG units, 154 TRS, 172 TRS; 8 TBS and 556 RS (as EB-57E); 4677 DSES, 4713 DSES (as EB-57E). To SAC Museum: 55-4244. Converted to EB-57E: 55-4237, 55-4239 to 55-4241, 55-4247, 55-4251, 55-4253, 55-4260, 55-4263, 55-4266, 55-4267, 55-4275, 55-4276, 55-4279, 55-4280, 55-4287, 55-4288, 55-4290, 55-4295, 55-4300. Preserved: 55-4244 (SAC Museum), 55-4274 (Pima Air Museum, Arizona), 55-4279.

Martin RB-57F: General Dynamics contracts–at least two contracts, received about 1962. Total of 21 RB-57F aircraft (rebuilt from RB-57As, B-57Bs, RB-57Ds), 63-13286 to 63-13302, 6313500 to 63-13503. Service with SAC; weather squadrons attached to Military Air Transport Service, (56 WRS, 58 WRS); 7407 CSW; various establishments for development work. To NASA: 63-13298 (as N928NA). Preserved: 63-13501 (Pima Air Museum, Arizona).

English Electric P.1A: Contract No. 6/ACFT/5175/CB7(a) for research prototypes received 1 April, 1950. Flight aircraft, WG760, WG763; plus a static test airframe. First flight dates: WG760, 4 August, 1954; WG763 18 July, 1955. WG760: Test flying, mainly at Warton and A & AEE, until September, 1962. To RAF Weeton as 7755M for ground training use. October, 1965 to RAF St Athan. November, 1966 to RAF Henlow for preservation. July 1982 RAF Binbrook for preservation. WG763: Test

flying, mainly at Warton, A & AEE, RAE Farnborough and Bedford, until June, 1963. To RAF Henlow as 7816M for preservation. August, 1982 to Manchester Air and Space Museum.

English Electric P.1B: Contract for three fighter prototypes, received 5 August, 1953, XA847, XA853, XA856. First flight dates: XA847, 4 April, 1957; XA853, 5 September, 1957; XA856, 3 January, 1958. XA847: Test flying mainly at Warton, until April, 1966. To RAE Farnborough for arresting trials. From November, 1969 stored at RAF Henlow. To RAF Museum, Hendon, November, 1971, (8371M allocated). XA853: Test flying as weapons development aircraft at A & AEE until 1964. Scrapped February, 1965. XA856: Test flying as engine development aircraft at Rolls-Royce, Hucknall, until 1967. Stored at Hucknall until scrapped in December, 1968.

English Electric P.1B Lightning: Contract No. 6/ACFT/10351/CB7(b) for fighter development aircraft, received 26 February, 1954. Twenty aircraft, XG307–XG313, XG325–XG337. First flight dates 3 April, 1958 to 26 September, 1959. None flying after 1970. Used for Firestreak trials: XG313, XG325, XG332. Used for Red Top trials: XG325, XG331, XG335–XG337. Service trials with AFDS: XG334–XG336. Used for F.3 development: XG309, XG310, XG327–XG329, XG331, XG333, XG335–XG337. To technical training schools: XG327 as 8188M at St Athan, XG329 as 8050M at Cranwell, XG336 as 8091M at Halton, XG337 as 8056M at Cosford. To Shoeburyness as gunnery targets: XG310, XG312, XG325, XG326, XG328, XG331. To Saudi Arabia: XG313 as G27-115 in 1968, for ground instruction. Preserved: XG337 (Cosford Museum), XG313/G27-115 (RSAF Dhahran).

English Electric P.11 Lightning Trainer: Contract for two trainer prototypes received 15 May, 1956, XL628, XL629. First flight dates: XL628, 6 May, 1959; XL629, 29 September, 1959. XL628: Design development flying at Warton until lost in Irish Sea on 1 October, 1959; XL629: Development flying at Warton and A & AEE until May, 1966. To Empire Test Pilots School, Farnborough, until 1975. Gate display aircraft at Boscombe Down from February, 1977.

English Electric Lightning F.1 and F.1A: First production contract received November, 1956 for 50 aircraft comprising 19 F.1 XM134–XM147, XM163–XM167; one static test airframe XM168; 30 F.1A XM169–XM192, XM213–XM218. First flight dates 29 October, 1959, to 28 July, 1961. F.1 aircraft: No. 74 Sqn: XM134–XM137, XM139–XM147, XM163–XM167. No. 111 Sqn: XM140, XM146. 226 OCU: XM134–XM137, XM139–XM141, XM143–XM147, XM163, XM165–XM167. AFDS for Service trials: XM135–XM138, XM163. Wattisham TFF: XM136, XM139, XM144, XM147, XM163. Leuchars TFF: XM135, XM139, XM144, XM145, XM164. Binbrook TFF: XM164. Used for development: XM134 (A & AEE and EE).

F.1A aircraft: No. 56Sqn: XM171–XM183. No. 111 Sqn: XM181, XM184–XM192, XM213–XM216. No. 5 Sqn: XM169, XM181, XM183. 226 OCU: XM171–XM174, XM177, XM178, XM180, XM182–XM184, XM188–XM190, XM192, XM214–XM216. Binbrook TFF: XM169, XM173, XM181, XM183, XM192. Leuchars TFF: XM169, XM173, XM174, XM178. Wattisham TFF: XM177, XM192. Used for development: XM169. Stored for spares (not assembled): XM217, XM218.

To technical training school: XM187 as 7838M at Newton. Used for RAF publicity display: XM191 front fuselage. Not delivered: XM170 (written off due to corrosion). Preserved: XM135 (IWM Duxford), XM144 (Leuchars), XM172 (Coltishall), XM173 (Bentley Priory), XM192 (Wattisham).

English Electric Lightning T.4: Second production contract received July, 1958 for 30 aircraft, XM966–XM974, XM987–XM997, XN103–XN112. (Ten aircraft, XN103–XN112, later cancelled). First flight dates 15 July, 1960, to 22 May, 1962. No. 19 Sqn: XM970, XM973, XM988, XM991, XM992, XM993. No. 23 Sqn: XM973. No. 56 Sqn: XM989. No. 74 Sqn: XM973, XM974, XM988. No. 92 Sqn: XM968, XM969, XM995. No. 111 Sqn: XM973, XM992. Lightning Conversion Squadron and 226 OCU: XM968–XM974, XM987, XM988, XM990, XM991, XM993, XM994, XM996, XM997. AFDS for Service trials: XM973, XM974. Used for development: XM966, XM968 (BAC and A & AEE). Converted to T.5 prototypes: XM966, XM967. To Saudi Arabia as T.54: XM989, XM992.

English Electric Lightning F.2: Third production contract, KC/2D/03/CB7(b), received December, 1959. 50 aircraft, XN723–XN735, XN767–XN803. (Later reduced to 44 aircraft, XN798–XN803 cancelled.) First flight dates 11 July, 1961, to 5 September, 1963. During 1966–70 30 aircraft converted to F.2A (XN724, XN726–XN728, XN730–XN733, XN735, XN771–XN778, XN780–XN784, XN786–XN793.)

F.2 aircraft: No. 19 Sqn: XN727, XN730, XN772, XN774–XN776, XN778–XN782, XN787, XN791, XN794. No. 92 Sqn: XN728, XN731–XN733, XN735, XN768, XN769, XN783, XN785, XN786, XN788–XN790, XN792–XN794. AFDS for Service trials: XN726, XN729, XN771, XN777. Used for development: XN723 (BAC and Rolls-Royce); XN724 (BAC and A & AEE); XN772, XN773 (Rolls-Royce). Converted for F.3 development: XN725, XN734. Converted to F.2A prototype: XN795. To Saudi Arabia as F.52: XN729, XN767, XN770, XN796, XN797. To BAC for ground training: XN734/8346M as G27-239.

F.2A aircraft: No. 19 Sqn: XN724, XN726, XN731, XN733, XN735, XN771, XN776–XN778, XN781, XN783, XN784, XN786, XN789, XN790, XN793. No. 92 Sqn: XN727, XN728, XN730–XN732, XN772–XN775, XN778, XN780, XN782, XN787, XN788, XN791–XN793.

Preserved: XN730 (Uetersen Museum, W. Germany), XN769 (West Drayton), XN776 (Museum of Flight, East Fortune, Scotland), XN784 (Air Classik, Munchengladbach, W. Germany), XN734/G27-239 (Aces High Ltd, North Weald, Essex, registered G-BNCA 10 December, 1986).

BAC Lightning F.3: Fourth production contract, KC/2D/049/CB.7(b), received June, 1960. 47 aircraft, XP693–XP708, XP735–XP765. First flight dates 16 June, 1962, to 26 September, 1964. No. 5 Sqn: XP694, XP701, XP702, XP706, XP741, XP750, XP751, XP753, XP754, XP764. No. 11 Sqn: XP694, XP695, XP701, XP702, XP706, XP707, XP737, XP741, XP748, XP749, XP753, XP761, XP764. No. 23 Sqn: XP706–XP708, XP735–XP737, XP750–XP751, XP756–XP761, XP763, XP764. No. 29 Sqn: XP694, XP695, XP698, XP700–XP703, XP705, XP707, XP708, XP735–XP737, XP743, XP745, XP747, XP755–XP759, XP763–XP765.

No. 56 Sqn: XP694, XP695, XP698–XP703, XP705, XP743–XP748, XP753, XP755, XP758, XP759, XP764, XP765. No. 74 Sqn: XP698, XP700, XP702–XP706, XP751–XP755, XP764. No. 111 Sqn: XP700, XP701, XP705, XP706, XP738–XP742, XP746, XP748–XP754, XP758, XP759, XP761, XP762. 226 OCU: XP696, XP707, XP737, XP740. Lightning Training Flight: XP694, XP706, XP707, XP741, XP749–XP751, XP753, XP764. AFDS for service trials: XP695, XP696, XP749, XP750. Used for F.3 development: XP693, XP694 (BAC and A & AEE), XP696, XP699, XP701 (A & AEE). Converted for F.6 development: XP693, XP697.
Preserved: XP745 (Boulmer), XP748 (Binbrook).

BAC Lightning F.3 and F.6: Fifth production contract, KD/2T/079/CB.7(c), received January, 1962. 45 aircraft, XR711–XR728, XR747–XR773. Later amended as follows: 16 F.3 aircraft (XR711–XR722, XR748–XR751), 16 F.6 (Interim) aircraft (XR752–XR767), 13 F.6 aircraft (XR723–XR728, XR747, XR768–XR773). First flight dates 6 October, 1964, to 28 February, 1966.
F.3 aircraft: No. 5 Sqn: XR713, XR716, XR718, XR749, XR751. No. 11 Sqn: XR713, XR718, XR720, XR749. No. 29 Sqn: XR715, XR716, XR720, XR751. No. 56 Sqn: XR716–XR721, XR748–XR750. No. 111 Sqn: XR711–XR716, XR719, XR720, XR748, XR750. 226 OCU: XR716, XR718, XR719, XR750, XR751. Lightning Training Flight: XR713, XR716, XR718, XR720, XR749, XR751. Used by A & AEE: XR717. Converted to F.53 prototype: XR722.
F.6 (Interim) aircraft: No. 5 Sqn: XR754–XR765. No. 23 Sqn: XR752, XR753, XR757, XR761, XR766, XR767. FCTU for service trials: XR752, XR753, XR766, XR767. All F.6 (Interim) modified to full F.6 standard 1967 to 1969. F.6 aircraft: No. 5 Sqn: XR724, XR726, XR747, XR752–XR756, XR758–XR761, XR763–XR765, XR767, XR768, XR770–XR773. No. 11 Sqn: XR723, XR724, XR727, XR747, XR752–XR763, XR765, XR769, XR771–XR773. No. 23 Sqn: XR723, XR725, XR727, XR728, XR752–XR754, XR756, XR758, XR760, XR762, XR763, XR765, XR766, XR770. No. 56 Sqn: XR725, XR728, XR756, XR759, XR761, XR764, XR770, XR771, XR773. No. 74 Sqn: XR725, XR758, XR759, XR764, XR767–XR773. No. 111 Sqn: XR752; Leuchars Pool Flight: XR752, XR757, XR758, XR765. Lightning Training Flight: XR724–XR726, XR728.

BAC Lightning T.5: Sixth production contract, received August, 1962. 20 aircraft, XS416–XS423, XS449–XS460. First flight dates 17 July, 1964, to 2 February, 1966. No. 5 Sqn: XS417, XS419, XS451, XS455, XS457, XS458. No. 11 Sqn: XS416, XS417, XS451, XS452, XS454, XS456–XS458. No. 23 Sqn: XS417, XS419, XS421. No. 29 Sqn: XS422, XS452, XS459. No. 56 Sqn: XS417, XS452, XS456, XS459. No. 74 Sqn: XS416. No. 111 Sqn: XS421, XS422, XS450. 226 OCU: XS417-XS423, XS449-XS455, XS457-XS459. Lightning Training Flight: XS416, XS419, XS420, XS452, XS456, XS457, XS459. ETPS: XS422.

BAC Lightning F.6: Seventh production contract, KD/2T/0139/CB.7(b), received January, 1964. 33 aircraft, XS893-XS904, XS918-XS938. First flight dates 15 March, 1966 to 30 June, 1967. No. 5 Sqn: XS894, XS895, XS898-XS903, XS919, XS921-XS928, XS931, XS933-XS936. No. 11 Sqn: XS895, XS897, XS899, XS901, XS903, XS904, XS918-

XS923, XS925, XS927-XS934, XS936, XS937. No. 23 Sqn: XS899, XS927, XS935-XS938. No. 56 Sqn: XS897, XS901, XS921, XS922, XS928, XS929, XS932-XS934. No. 74 Sqn: XS893, XS895-XS897, XS920, XS921, XS927.

BAC Lightning T.5: Eighth production contract, received October, 1964. Five aircraft (unconfirmed serials XS851-XS855) initially, increased to eight aircraft. Contract later cancelled; two partly complete aircraft transferred to tenth production contract, and three others to Saudi contract.

BAC Lightning F.6: Ninth production contract, received about late 1964. 12 aircraft. Contract later cancelled; seven partly complete aircraft transferred to Saudi contract.

BAC Lightning T.5: Tenth production contract, received about early 1966. Two aircraft, XV328, XV329. First flight dates 22 December, 1966 and 30 December, 1966. No. 5 Sqn: XV328. No. 29 Sqn: XV328. No. 74 Sqn: XV329.

Lightning overseas orders:

BAC Lightning T.54: First export contract received March, 1966. Customer–Saudi Arabia. Two aircraft, 54-650, 54-651 (ex-RAF T.4s XM989, XM992). Delivered in June, 1966. Both served with No. 6 Sqn RSAF. Preserved: 54-650 (Dhahran).

BAC Lightning F.52: Second export contract received April, 1966. Customer–Saudi Arabia. Four aircraft, 52-655 to 52-658 (ex-RAF F.2s XN767, XN770, XN796, XN797). Delivered in July, 1966. Fifth F.52 added later, 52-659 (ex-RAF F.2 XN729, used Class B registration G27-1 before delivery). Delivered in May, 1967. All served with No. 6 Sqn RSAF. Preserved: 52-655 (Dhahran), 52-656 (Riyadh).

BAC Lightning F.53 and T.55: Third export contract received May, 1966. Customer–Saudi Arabia. Forty aircraft comprising 34 F.53, 53-666 to 53-699; and six T.55, 55-710 to 55-715. First F.53, 53-666, conversion of ex-RAF F.3, XR722 (53-666 used Class B registration G27-2 before delivery; 53-667 to 53-699 used G27-37 to G27-69). First T.55, 55-710, conversion of ex-RAF T.5 XS460. (55-711 to 55-715 used Class B registrations G27-70 to G27-74 before delivery). Two replacement aircraft added, one F.53, 53-700 (replaced 53-690, used G27-223) and one T.55, 55-716 (replaced 55-710, used G27-75). All new F.53 and T.55 first flight dates in period July, 1967 to December, 1968; except 55-716 in July, 1969 and 53-700 in June, 1972. All deliveries in period July, 1968 to September, 1969, except 53-700 in September, 1972. Service with Nos. 2 and 6 Sqns RSAF, and the Lightning Conversion Unit at Dhahran.
Preserved: 53-699 (Tabuk).
Aircraft returned to the UK in January, 1986: 18 F.53 and four T.55 as follows: 53-668, 53-670, 53-671, 53-672, 53-675, 53-676, 53-681, 53-682, 53-683, 53-688, 53-691, 53-693, 53-700, 53-679, 53-685, 53-686, 53-692, 53-696, 55-714, 55-715, 55-711, 55-713 with British serial numbers ZF577–ZF598 respectively. Stored at Warton.

BAC Lightning F.53K and T.55K: Fourth export contract received December, 1966. Customer–Kuwait. Fourteen aircraft, comprising 12 F.53K, 412 to 423, and two T.55K, 410 and 411. (F.53Ks used Class B registrations G27-80 to G27-91 before delivery; T.55Ks used G27-78 and G27-79.) All first flight dates in the period May, 1968 to September, 1969.

All deliveries in period December, 1968 to December, 1969. All remaining aircraft in storage by 1977.

BAC TSR.2: contract received 6 October, 1960, for nine development aircraft, XR219–XR227, designated Type 571. Only first two completed and only XR219 flown. Contract for second batch of 11 pre-production aircraft, XS660–XS670, designated Type 579, received 28 June, 1963. Contract for materials for third batch of 30 production aircraft, XS944–XS954, XS977–XS995, designated Type 594, received 20 March, 1964. Project and all contracts cancelled on 6 July, 1965.

Construction Numbers

English Electric/BAC Warton have never used construction numbers. However, certain numbers are frequently referred to as construction numbers, in particular the EEP71000 series for Canberras and the EEP95000 series for Lightnings. These numbers are front fuselage inspection serial numbers, used for inspection record purposes. All large airframe components have their individual serial numbers which are unchanged for the life of the component, no matter which aircraft it may be fitted to during that life. Therefore the Canberra EEP71000 and Lightning EEP95000 numbers associated with particular aircraft change if the aircraft has a change of front fuselage. Such changes were common for Canberras, and there were several Lightning examples. Hence these series of numbers are very unreliable if they are considered as construction numbers. For this reason, they are not quoted for Canberras or Lightnings, or any other EE/BAC type.

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AIRCRAFT INDEX

The indigenous products of the companies described in the book can be found with the aid of the Contents. This index lists aircraft type names not given in the Contents and mentioned outside their own chapters.

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GUIDED WEAPONS INDEX

The design, development and histories of all English Electric types from the Wren to the Lightning, as well as the earlier aircraft of the Phoenix, Coventry Ordnance Works and other related companies.

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